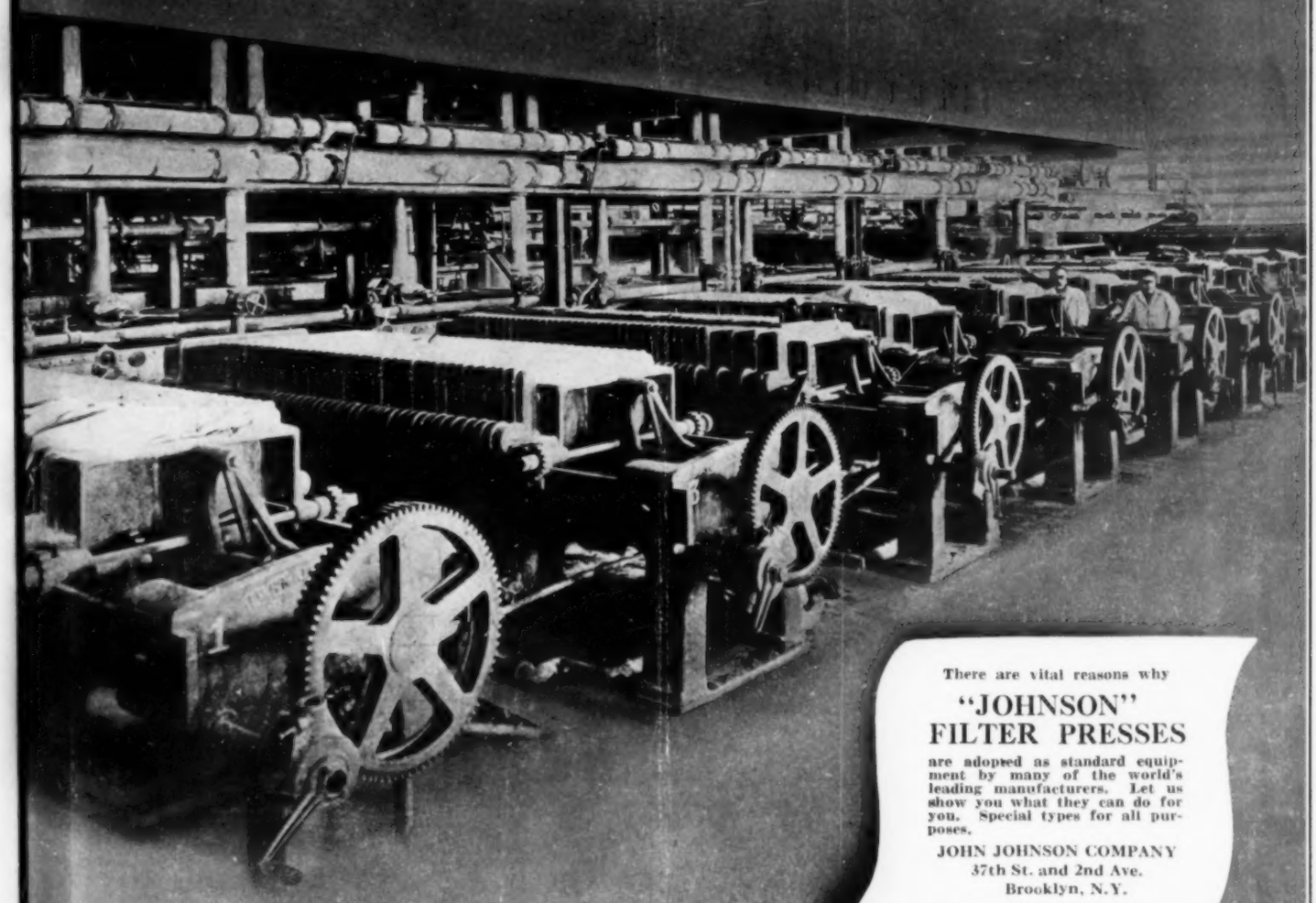
York, N. Y., Nov. 26—Dec. 3, 1919 McGraw-Hill Co., Inc. Vol. XXI, No. 13, 25c. a copy

CHEMICAL & METALLURGICAL ENGINEERING



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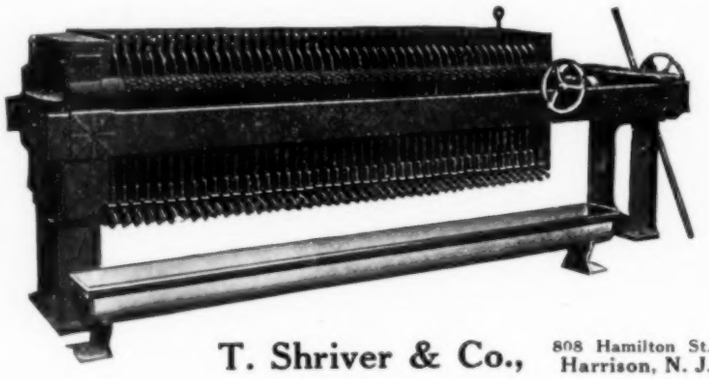

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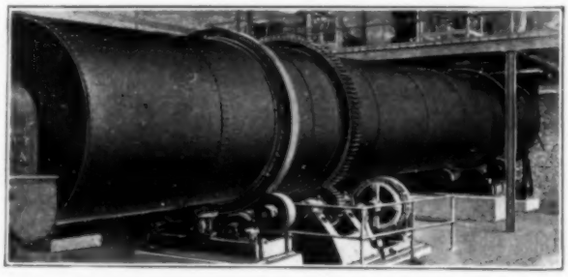

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Published December 18th, With Current News

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

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Volume 21 — New York, November 26—December 3, 1919 — *Number* 13

Approaching Normal Publication Dates

LOOKING back through the pile of letters of encouragement which arrived during the time when publication of CHEMICAL & METALLURGICAL ENGINEERING was suspended certainly impresses us with the idea that the thinking public is sick and tired of strikes to extinction, and has little sympathy indeed for the bludgeoning attitude lately so much in evidence. As an instance:

> Not that you need, but that it may aid in sustaining your moral position, I, a subscriber, state I am in sympathy with your action.
>
> You are justified in any reasonable expedient to meet the conditions imposed upon you, and would be sustained by men like me if you asked extra financial support (if you are overtaxed) or a reduction in service pending the solution of this dilemma.

Unfortunately it was physically impossible with the whole local industry paralyzed to continue the service as we wished and worked for; however, we feel we are getting rapidly out in the open. Double editorial sections will correctly complete the volumes without an undue tax on either subscriber or advertiser. Complying with postal regulations is rather a difficult task, but even a casual reader can see that these issues are timely in all respects except the date line.

Importance of Data On Small Volume Changes

ALTHOUGH numerous investigators have been making measurements of thermal expansion ever since LAVOISIER and LAPLACE began fairly accurate work of this character more than 135 years ago, the field to be covered has been scratched only at a few points. For instance, the total data on linear and cubic expansion of solids recorded in the 1916 edition of the Smithsonian Physical Tables occupy only two and one-half octavo pages, and most of the values given are derived from measurements of great antiquity. In the elaborate collection of physical constants issued by the French Physical Society in 1913, LE CHATELIER begins the section devoted to metallic alloys with the statement: "It is impossible to find numerical information concerning the physical properties of alloys which is worthy of any confidence."

A detailed description of A. W. GRAY'S very convenient dilatometer should therefore serve to impress many experimentors with the fact that it is comparatively easy to determine such missing but important data with great precision. Its many applications to the field of structural engineering and machine design do not need to be enlarged upon.

For pure metallurgical research, however, the method is worthy of careful consideration. Thus, dimensional changes during transition can be made the basis of a dilatometric method of thermal analysis which may reveal important new information. A knowledge of the magnitude of these changes is of particular importance when the materials have to be carried through such a region in the course either of their manufacture or of their ordinary use. Such knowledge would, for example, aid in determining the safe rate for heating or cooling large metal ingots.

The dilatometer can be made to throw light upon structural changes which take place at constant temperatures. As an instance, season cracking in bronzes, which has caused so much trouble in the water-supply equipment of New York City and in other cases, appears to be due in part to the action of differential expansions starting minute cracks which are greatly increased by the combined action of dimensional changes and corrosion.

More About American Dyes

PROTECTION against insidious German competition in dyes and allied chemicals is again urged by the President in his message to Congress, just convened. Quoting from his last message urging such legislation, he says:

"Among the industries to which special consideration should be given is that of the manufacture of dyestuffs and related chemicals. Our complete dependence upon German supplies before the war made the interruption of trade a cause of exceptional economic disturbance. The close relation between the manufacturer of dyestuffs, on the one hand, and of explosives and poisonous gases on the other, moreover, has given the industry an exceptional significance and value.

"Although the United States will gladly and unhesitatingly join in the program of international disarmament it will, nevertheless, be a policy of obvious prudence to make certain of the successful maintenance of many strong and well-equipped chemical plants. The German chemical industry, with which we will be brought into competition, was and may well be again a thoroughly knit monopoly capable of exercising a competition of a peculiarly insidious and dangerous kind."

But we fear the public as well as the Congressional mind has become rather confused by the many extraneous factors which have been introduced into the discussion. It is not a problem of foreign exchange, nor yet of the welfare of the men who have engaged in the manufacture of dyes in this country. The real problem is that of a vast German trust against what is still an infant industry. They can still make four times as many dyes in Germany as are made here. And they are going to make Americans sweat for what

they sell. The German choice in the matter would be to make the American makers of dyes suffer, rather than the users. They want this market, more particularly because other countries have either adopted the license system, and thus closed the Germans out, or they are in the process of doing so. Each nation wants national independence in dyes.

Now the merit of national independence in dyes is that it provides for an academic army of chemists organized to work in the organic field, and prepared to make explosives, gases, and the many unexpected products needed in war. If we want such a body of men for the same reasons that England, France, Italy and Japan do, we must have the industry. We cannot have the men without the industry.

It is not a controversial subject between textile men and chemical manufacturers. Whatever happens, textile manufacturers will have to pay, and pay well, for their dyes. It is only a matter of time whether we let the German products in or keep them out. If we let them in they will be cheaper only until the American industry is extinguished, after which, of course, the Germans will be able to charge their own prices. The real question involved is not whether one industry or another makes more or less profit, or whether the American dye manufacturers incur heavy losses. The question is, Do we want the comprehensive preparation for war that can be obtained only by the active support of the dye chemist? If we do, there is but one way, and that is to exclude imports by a license system. A higher tariff alone will not do it.

A Thought on Labor's Goal

AT ONE of the critical periods of the war the British Minister of Education, ALFRED HENDERSON, who was also general secretary of the Labor Party, became convinced that the way to achieve peace was by negotiation with the German authorities. As this was not in accord with the policy of the Allies, his resignation as a member of the Cabinet was accepted. While to the British Government the change in personnel involved in his retirement was but an incident in the day's work, HENDERSON took it as a personal affront. He held that he was persecuted for his honest convictions, and he made his appeal to Labor for peace by negotiation while the Germans still occupied Belgium and northern France. So strong was this argument in regard to the invulnerability of the Hindenburg line and the uselessness of continued struggle that Labor was disposed to follow him, and the production of munitions in England straightway fell off in increasing ratio. To offset this a number of American labor leaders were invited to visit England and other allied countries, to carry to the workers of those lands the doctrine held in America by both capital and labor—that the only way to end the war was to win it. The mission was successful.

The following conversation has been reported to us, between one of the American leaders and a French professor of law at the Sorbonne whose philosophy of politics is of a socialistic turn:

"What," asked the professor of the American, "is the goal of organized labor in your country?"

"I do not know." was the reply.

"Then you are bound to fail. You cannot make progress if you do not know what you want."

"Possibly," conceded the American, "but I cannot reach the conclusion that we should do better with a specific program. We have in our country a very able instrument called the Constitution. It was drawn by a body of men of consummate ability and lofty character. Speaking for myself and my associates in the organization of labor in the United States, we are not to be compared with them in ability or vision. But not one of those men had ever seen a railway, or a steamboat, or a line of telegraph wire. News and goods were carried by the wind at sea, and by horses and mules on land. Machinery of the modern type and industrial life as we know it today were undreamed of by them. Therefore it occasionally happens that important and needed legislation is forbidden by the letter of some article of the Constitution that was designed for entirely different conditions. Then the pundits of the law are driven to the most remarkable talmudic twistings of the Constitution to make necessary legislation possible. Sometimes they cannot do this, and then long delays involving injustice and suffering ensue.

"Now, we have ideals of physical welfare and of intellectual standards that we hope to see labor realize, but these are neither definite nor fixed. We feel that we do not know enough to legislate for the men and women who will toil fifty or a hundred years from now. We push ahead where we can, and sometimes we make mistakes. Sometimes mistakes are made, in spite of our efforts to prevent them. But we do not want to make our errors permanent. It seems better, on the whole, to trust to the future, and to the intelligence of those who are to come after us, rather than to guess blindly, and to run the risk of guessing wrong."

We should like to hear more of such talk, and hope the time may soon be at hand when this quality of frankness will be the habit in general discussion. There is not sufficient confidence to warrant it yet, and we believe there are too many undeveloped and immature minds engaged in the councils of labor to permit to their leaders that freedom of speech that wholesome discussion demands. The same may be said of many groups of employers of labor. They have "put over" too many tricks in the past to have won the confidence of their employees.

There isn't any egg-of-Columbus solution to the labor situation. It must be based on confidence, and there isn't enough of it. Traditions are bad on both sides. In the big shake-up that the world has undergone a great deal has come up from the bottom that is far from admirable. There are many loud voices heard with neither character nor understanding back of them. Now, character is essential. The German Government got along for many years without it and seemed to prosper, but it didn't last. Character is social protein, and we must have it if we would endure. A great many labor unions have not yet learned that an agreement is an obligation, and it will be a long time before some of them do learn it. They will have to be made up of a more intelligent membership, a membership than can figure on consequences, before this can be expected. But collective bargaining by men of character and intelligence will come about if we have a great deal of faith and patience in spite of many disappointments. With the present growth of a sense of obligation among employers we believe it will soon spread among employees; and when that comes about we may look for sudden rises in efficiency curves.

Steel Prices And Service

ONE may regard it as simply an incident following the war-time control of steel prices that there has been so little fluctuation in the steel market in the past twelvemonth, but there is probably a permanent influence at work, one that makes "service" count in the competition. There must be competition of one description or another. It was competition made the American Navy what it is, competition between men, gunner's crews and vessels. There is some competition that is not advantageous. When railroads were debarred from cutting passenger rates they indulged in wasteful competition as to the convenience of service, whereby many railroads lost money on their passenger service and operated more trains than were needed to accommodate the public.

Competition in steel service may be popularly described as "all to the good." Fitting the steel to the particular employment intended by the customer makes for progress, as consumption is encouraged, and the seller, having found a steel that meets the requirement of a certain consumer, is in position to offer the same class of steel to another consumer who he knows has the same problem.

Service in steel means much more than furnishing steel of the particular character desired. It involves regular delivery as well, and not only regular delivery, but ability to modify specifications that are on file and to transpose the order in which specifications are to be filled. As a practical matter ability on the part of the mill to render delivery service to the customer depends upon system. The better the system of handling orders the more readily modifications can be made.

By no means, however, does the whole matter rest with the manner in which orders or specifications are handled after they are received. The work starts with the sales department, whose duties formerly were regarded as being confined to selling as much tonnage as possible and at as high prices as possible. Now the duties and responsibilities of the sales department are much broader. It must pick the best customers, those whose orders will prove most profitable, price and actual cost of production being considered. It must endeavor to sell tonnages that will stay sold and to customers whose trade can be counted upon year after year. The sales department and the operating department work more and more closely together.

The railroad furnishing the best passenger service may make the least money. The steel mill furnishing the best service should make the most money, for the rendering of good service is the result of system and efficiency, which are always certain to pay. Opportunity for competition or rivalry being afforded, there is less occasion for price competition, hence market prices have less disposition to fluctuate.

Service means holding customers, hence an intimate relation between producer and consumer is built up and the producer has not the former incentive to encourage buyers to place orders farther and farther ahead. Some of the great buying movements of the past in the steel market were produced by tactics directly calculated to induce buyers to place contracts for another quarter or half year, and then for still another period. The later policy is to sell only a reasonable distance ahead and to take regular customers on for another delivery period when the proper time arrives. Accordingly the sales department is not bent upon selling the mill up for greater and greater distances ahead, but upon making sales commitments with which the subsequent orders or specifications will closely harmonize. The salesman is helping to run the mill efficiently instead of gathering up orders promiscuously and letting the mill take its chances in filling them.

Imagination And Success

COLONEL JOHN J. CARTY of the American Telephone & Telegraph Co. has honorary degrees from universities and decorations from Governments and emperors and kings enough to satisfy almost anyone. Lately, however, he has received two more: the Distinguished Service Medal of the United States, and Commandant of the Legion of Honor of France. His achievements in establishing communications at the battlefront and elsewhere during the war have already been discussed and acknowledged, and the present official recognitions are abundantly warranted.

We recall after the war with Spain a little script that had an enormous circulation, called "A Message to Garcia." It told of a Navy Lieutenant who had a message to deliver, and he delivered it. This called for energy and perseverance and pluck and all the virtues which we may safely include in our advice to young men who are making a good start. CARTY'S task was different; it called for a measure of invention that is beyond most of us, as well as the inspiration of a great force of men and women to pull together, to work and to endure with patience and with all their minds and hearts until the dawn of victory.

Once upon a time when the telephone company was in its beginning he was only one of a number of men working with their wires, until it was observed that he used his head outside of business hours. Then when the problems of the day seemed insoluble it was CARTY who had been thinking over what might happen and who had a solution ready. He had the knack of calling upon his own intellectual reserves and making them work. Others might have done it, perhaps, but he was the one who did, and so they made him chief electrician —because they had to call him something that indicated authority. That was the start, and those marvelous reserves of his have been functioning in applied science unto this day. In telephony his is usually the last word in the art, and he is not an old man yet, by any means. Of course his native gifts were unusual, and but few of us have such endowments of imagination coupled with precise and mathematical thinking.

We refuse to practice hypocrisy, and to tell any boy who works for the telephone company that he may follow in the footsteps of Dr. CARTY. The chances are against it. But while no two of us are alike we have, or the most of us have, the gift of imagination, and in the work to which we refer we find his imagination constantly in function.

In taking a cue from his career if we were to offer advice to young men we should restrict ourselves to those who have the gift of wondering about things. Then we should urge upon them to take this gift along with them into daily life and after a while to see what dreams come true. If it seems straining a point to say that the sound of the harp that once through Tara's halls its soul of music shed may accompany higher mathematics and physics—here's the evidence of it.

Readers' Views and Comments

Contributions by Metallography to L'Art Nouveau

To the Editor of Chemical & Metallurgical Engineering

SIR: Those who saw the Post-Impressionist Exhibition of paintings and sculpture held in New York shortly before the war will recall that one of the most engaging canvases bore the title, "Nude Descending a Staircase," that it might have hung with propriety in

FIG. 1. AJAX DEFYING THE LIGHTNING
Brass (Cu 67, Zn 33) annealed ½ hr. at 650 deg. C. and ½ hr. at 850 deg. C.

any Sunday School library, and that all that was visible to the properly naked human eye was the effigy of many shingles flying through the air. Those who have followed the Cubist and other Post-Impressionistic schools of art will immediately recognize in the accompanying

FIG. 2. ALASKAN SNOWS
Brass (Cu 67, Zn 33) annealed ½ hr. at 550 deg. C. and ½ hr. at 850 deg. C.

microphotographs taken from a paper by F. G. Smith read before the Institute of Metals Division the remarkable designs which develop in twinned crystal forms of certain non-ferrous metals, more especially in brass and alloys of tin.

Fig. 1 indicates, from a Cubist standpoint, a representation of Ajax Defying the Lightning. Ajax will be recognized as standing at the extreme left, in the shadow of a rock in the lower left foreground (which explains his dark color). The lightning is clearly defined in bold zigzag strokes, and the flying timbers at the left indicate a Kansas cyclone. The somewhat exaggerated but subtle note of a blown leaf is rather distinctive of Matisse than of Pares. The real origin of the picture is a field of twinned crystals in brass: (67 per cent Cu, 33 cent Zn) reannealed at 850 deg. C. for ½ hr. after ½ hr. at 650 deg. C.

The same brass reannealed for ½ hr. at 850 deg. C. after ½ hr. at 550 deg. C. reveals a remarkable Cubistic impression of Alaskan Snows. The door of the prospector's cabin is shown on the right, with the surging billows of snow in the foreground on the left. The

FIG. 3. THE APPROACHING STORM
Same as Fig. 2 after 3000 kg. pressure and reannealing

study is full of pathos, showing the cabin door open to the blast, the frail tenement obviously abandoned, while the observer perceives in the visible distance the rear of the dog-sled as it is drawn away. This indicates that the prospector is out of provisions, and is setting forth in quest of food. The sub-title might well be The Drive of Hunger.

The structure shown by a field of the same brass that has been under 3000 kg. pressure after reannealing under the same conditions as in the case of that shown in Fig. 2 is entitled, as a picture, The Approaching Storm. One sees the deluge of rain beating against a

FIG. 4. WOUNDED BIRD IN NEST
Alloy (Sn 70, Sb 20, As 5) etched 12 hr., × 4

wayside signboard on the right, while on the left the lightning flashes through the sky and rends the brown bosom of the earth.

Very different indeed are the results obtained by alloys of tin with arsenic and antimony. The accompanying microphotographs are of crystals found in a ternary system between tin, antimony and arsenic. Fig. 4 shows a Sn 70, Sb 20, and As 5 per cent alloy etched 12 hr., × 4, and reveals the change of cuboidal crystals into curvilinear forms as the arsenic content reaches approximately 5 per cent. The value of these designs in Cubistic art is slight, but if we hark back to the long, curved lines of that phase of draughtsmanship following Aubrey Beardsley and his cult, we find them full of inspiration. We have named Fig. 4 Wounded Bird in Nest. Of course wounded birds do not usually take to their nests, but we claim the privilege of artistic license.

No. 5, which is an alloy of Sn 77, Sb 18, and As 5 per cent, contributed, as in the case of No. 4, by Messrs. Stead and Spencer at a recent meeting of the older organization, the Institute of Metals of Great Britain,

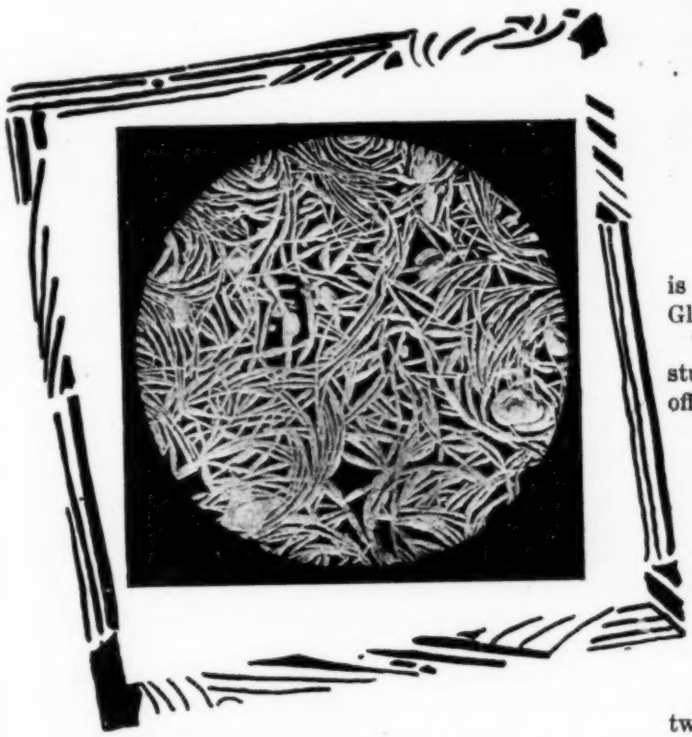


FIG. 5. MORNING GLORIES IN THE RICE-FIELDS AFTER A STORM

FIG. 6. THE HOST
($CaSO_4$, $2H_2O$)

is a Japanese scene which might be called Morning-Glories in the Rice-fields After a Storm.

We have heard so much of the need of Art courses for students engaged in science and engineering that we offer this sketch to demonstrate that our metallographers are making contributions fully as good as, if not better than, the most advanced of the school of Post-Impressionist painters.

To prove our contention we submit along with the microphotograph of the metallographers a bona fide reproduction of a piece of modern sculpture now on exhibition at the famous galleries of Messrs. Knoedler & Co. on Fifth Avenue, New York. It is entitled "The Host," and is by the well-known artist Elie Nadelman. It stands about two feet in height as we recall the original, and the price in plaster is eight hundred dollars.

MARTIN SEYT.

University and College Endowment

To the Editor of Chemical & Metallurgical Engineering

SIR:—In these days when the demands upon our income are more multitudinous and insistent than ever before there is greater need and reason than ever that each new claimant present as clearly and convincingly as possible the facts upon which his claim to support is based, and as the Massachusetts Institute of Technology has found it necessary to appeal to its friends for the great sum of $10,000,000 I shall be grateful if you can allow me the space required to state briefly the case for the Institute and the justifying reasons for this appeal.

The international standing of the Institute as probably the foremost school of technology in the world is generally recognized and further demonstrated by the fact that its student body includes a larger proportion of foreign pupils than any other institution in the country, while the influence of the school upon our own industrial development has been far reaching and profound. This was strikingly brought out at the Congress of Technology held in 1911 in commemoration of the fiftieth anniversary of the signing of the charter of the school. The papers presented by Institute graduates at that time covered the entire field of engineering and science in their applications to industry. The fundamental principles on which the school is founded are the importance of being useful and the way to learn is to do, and these principles have been consistently practiced and developed for more than half a century.

That the community is not unmindful of the value of the Institute training is shown by the recent phenomenal and even embarrassing increase in the number of its students. The magnificent new buildings in which the school is housed were, with what seemed to be ample foresight, designed to accommodate an attendance of 2000, and until this year the student body was well below that figure. This year the number of students has suddenly jumped to more than 3000, thereby straining to the utmost the physical equipment of the school and placing an undue burden upon an already overworked teaching staff.

The devoted and highly trained teachers who constitute the faculty of the Institute have no thought of turning aside from the pressing problems which confront them, but can a self-respecting community continue indefinitely to accept such loyal service without removing the present necessity of sacrifice which it entails? Under normal conditions a member of the teaching staff at the Institute, after an expensive education, is about 30 years of age when he is made assistant professor at a salary of $2000, and about 40 years of age when he becomes a full professor at $3000. The average salary of the full professors is now $3600, and only five out of a staff of nearly 300 receive the maximum salary, which is $5000. Under the present economic conditions it is obviously difficult and may soon become impossible for men of this capacity to resist the constantly increasing pressure from the industries. Dr. Maclaurin, the president of the Institute, states that if this condition continues for five years the results will be most serious and if it continues for ten years the results will be disastrous. It is to remedy this condition and to provide the new facilities required for housing and training the men who are seeking its instruction and upon whom the industrial future of our country must so largely depend that the school calls for these new funds and confidently directs that call to all those who believe in the importance of being useful.

ARTHUR D. LITTLE.

Cambridge, Mass.

M.I.T. Alumni Vocations

In connection with the endowment campaign now going on among the alumni and friends of the Massachusetts Institute of Technology, approximate figures have been compiled which indicate the relative distribution of the graduates in industry. It appears that about one-half practice the engineering professions, one-quarter go into manufacturing and the remainder follow lines in which their engineering education can have beneficial application.

There have been 14,000 registered students at Tech. and 7015 graduates, 6000 of whom are included in the following classifications. The groups are somewhat arbitrary and might be re-arranged. However, the subclasses are not definite enough to permit any very detailed deductions. The professional engineers' class is mainly made up as follows:

ENGINEERING PROFESSIONS CLASSIFICATION

Electrical engineers	560
Teachers of engineering	503
Mechanical engineers	446
Railroad engineers	322
Architects	301
Civil engineers	262
Draftsmen	64
Naval architects	40
Marine engineers	44

The chemical, metallurgical and mining engineers will be included in the manufacturing class because it is assumed that the majority are so engaged. The mechanical engineers are also extensively occupied in manufacturing, and the number so engaged approximately offsets the engineers erroneously included in the following manufacturing classification:

MANUFACTURING CLASSIFICATION

Mining and metallurgical engineers	351
Miscellaneous manufacturing	350
Manufacturing chemists	252
Steel and iron companies	161
Textile companies	105
Chemists	90
Rubber companies	59
Soap and glue companies	44
Paper companies	40
Gas companies	36
Sugar and starch companies	28
Powder and explosives companies	26
Electrochemical engineers	28

The small number of men reporting themselves as chemists is quite illuminating, when it is considered that several times this number have graduated as chemists. However, this is no reflection on the chemical course given, for it may rightly be assumed that the training of these missing chemists has been such that they could apply themselves more profitably out of the laboratory. The course a man takes does not necessarily have everything to do with his final vocation. David Wesson graduated as a metallurgical engineer, and no doubt he was an able one. However, better opportunities opened up in the edible-oil industry and he applied his thorough Tech. Met. training to this field, with the well known result that the name Wesson has largely supplanted that of olive in the edible-oil industry.

The benefit of our technical institutions to the community is much broader than can ever be appreciated, and it is hoped that the community will generously square up a few of the silent but evident bills receivable now held against it.

National Conference of Business Paper Editors

Responding to the call issued by Samuel O. Dunn, president of The Associated Business Papers, Inc., in pursuance of the resolution adopted by the executive committee of The Associated Business Papers, Inc., at New York, Oct. 6, 1919, 67 editors and editorial representatives assembled at the Hotel Astor, New York City, Nov. 13, to consider the formation of an editorial conference of The Associated Business Papers, Inc. It was decided to form a National Conference of Business Paper Editors, the purpose of which is:

To provide an organization for the discussion and formulation of constructive editorial policies, held in common by the business press; to furnish the medium for disseminating the results of these discussions through co-operation; to provide by close contact of the editors, inspiration for editorial achievement and the fuller realization of the existing individual and collective responsibility as leaders of thought in the industries they serve; and to perform such other functions as may further the aims of this Conference.

The officers elected are: President, A. I. Findley, *Iron Age*, New York; vice president, Clay Cooper, *Mill Supplies*, Chicago; secretary-treasurer, R. Dawson Hall, *Coal Age*, New York; executive committee, J. C. Chase, Class Journal Co., New York; B. O. Hough, *American Exporter*, New York; W. R. McQuilkin, *National Builder*, Chicago; E. T. Hawson, *Railway Maintenance Engineer*, Chicago; C. J. Stark, *Iron Trade Review*, Cleveland; Harvey Whipple, *Concrete*, Detroit.

There will be three meetings each year, one in midwinter, one in the spring and the third in conjunction with the annual meeting of The Associated Business Papers, Inc. One of the two editorial meetings will be held in the East and the other in the West. Special meetings may be called at the discretion of the executive committee.

The time and place for the midwinter meeting was left to the discretion of the executive committee.

Extension of Trading-With-the-Enemy Act

Continuation of the trading-with-the-enemy act until Jan. 15 has been provided by a joint resolution passed by the Senate and the House of Representatives. The resolution was made necessary because of the possibility of ratification of the Peace Treaty by the Senate. Ratification of the Treaty would terminate the trading-with-the-enemy act and would permit the dumping of German dyes, as no law has been enacted to protect the domestic dye industry. While the House has enacted such legislation, the Senate, due to the consideration of the Peace Treaty, was unable to take up the consideration of the dyestuffs bill. The resolution which has been adopted by the two houses provides "That notwithstanding the prior termination of the present war, the provisions of the trading-with-the-enemy act, approved Oct. 6, 1917, and of any proclamation of the President issued in pursuance thereof, which prohibit or control the importation into the United States of dyes or other products derived directly or indirectly from coal tar, are continued until Jan. 15, 1920." The only objection which was offered, and that later was withdrawn, was caused by a telegram from a textile manufacturer which read as follows: "Very important for cotton mill industry that foreign fast color dyes are admitted without further delay or hindrance. One cotton manufacturer has a million and a half dollars worth of shirting cloth requiring these dyes. He is unable to deliver it without the dye. Meanwhile many million dollars worth of these shirtings with fast dyes recently have been bought in England for importation to this country. Our print works has many thousand pieces held up for lack of fast colors. We certainly will lose our export trade in shirting unless permitted to secure dyes available to foreign competitors."

During the discussion of the resolution, it was stated on the floor of the Senate that the War Trade section of the State Department is not functioning as efficiently as it should. It is anticipated that the resolution will have to be extended, as it is not probable that the consideration of the dyestuffs bill will have been completed by Jan. 15. The Senate is unalterably opposed to the licensing system, and Senator Smoot of Utah, as strong a protectionist as he is, declared in the course of the debate that he would not vote for a license system even though he knows it to be necessary to the protection of the dyestuffs industry.

Anti-Tuberculosis Campaign

While science is making rapid strides in chemistry, adding each year to the productivity and comfort of the civilized world, the physical vigor of that world is threatened by an insidious disease. The centuries-old plague—tuberculosis—is now killing hundreds of thousands of persons and incapacitating millions every year in three big nations for which reliable figures are available. In each of these nations, Great Britain, France and the United States, a determined effort is being made to check the ravages of the disease, which, experts agree, is not hereditary and is both preventable and curable.

The death toll in the United States is 150,000 a year, the active cases number more than 1,000,000 and the unsuspected cases greatly exceed the known. To combat this menace the National Tuberculosis Association has undertaken an intensive campaign on such a scale as to warrant expectations of saving tens of thousands of lives and averting the physical breakdown of many thousands of workers as the result of a year's work. The amount required for a nation-wide drive against the "White Plague" will be approximately $6,500,000, which fund will be raised during December by the sale of Red Cross Christmas seals at a penny each.

Working in co-operation with its 1000 affiliated State and local organizations, the National Tuberculosis Association plans to carry to the great masses of the people the simple truths regarding the disease—that it is most effectively fought by fresh air, scrupulous cleanliness and good food, which build up the bodily resistance against disease germs. Employers are to be impressed with the necessity of keeping up to the minute in providing protective devices against dust and dyes and impure air, which weaken the lungs and thereby increase the danger of tuberculosis. Physicians everywhere will be asked to redouble their efforts to search out unsuspected cases, and communities will be urged to provide clinics, dispensaries, hospitals and sanatoria in sufficient numbers to assure proper treatment for all afflicted persons. By such means it is believed that a long step will be taken to the great goal, which is the bringing of the disease under complete control.

Savannah Meeting of the American Institute of Chemical Engineers

Report of the Annual Meeting Held at Savannah, Georgia—Election of Officers—Address of President-Elect David Wesson on the History and Development of the Cottonseed Oil Industry—Excursions

FOR several reasons the selection of Savannah is preference to one of the usual convention centers for the twelfth annual meeting of the American Institute of Chemical Engineers proved to be a very happy one. The four days, Dec. 3–6, were ideal, thus adding to the pleasure of those in attendance while getting better acquainted with one another as well as with the hospitality of Georgia. It was peculiarly fitting that recognition should be made on the twentieth anniversary of the process of refining cottonseed oil as devised and first operated in Savannah by the Institute's president-elect, Dr. David Wesson.

The commodious tourist hotel DeSoto was opened in advance of the usual winter season schedule especially, that its homelike attractions might give the meeting seclusion and an atmosphere of a great family gathering. The Hon. Murray M. Stewart, mayor of the city, gave the address of welcome, to which President Arthur D. Little responded. The reports of committees were received. That on the canvass of ballots reported the following officers elected:

President, David Wesson; first vice-president, Henry Howard; second vice-president, Albert W. Smith; third vice-president, Hugh K. Moore; secretary, John C. Olsen; treasurer, F. W. Frerichs; auditor, C. F. McKenna.

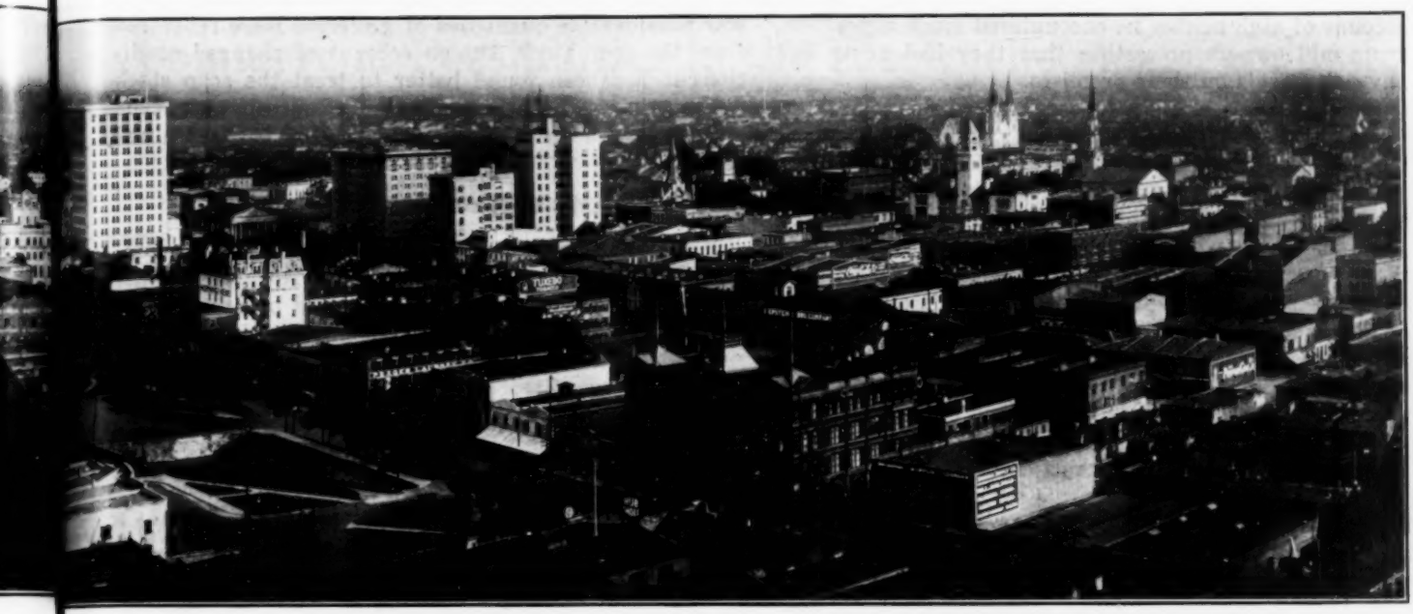
In the annual report of Secretary Olsen, it was stated that the total membership of the Institute had reached 344. This led to considerable discussion. Dr. Little stated that there were at least 2000 chemical engineers in this country and with such a restricted membership the society could not be considered as unqualifiedly representing the profession. It was finally decided that the council, when it seemed desirable, could waive any or all the qualifications required by the constitution for an applicant to have his name placed on the ballot. This was especially designed to bring into the society certain men of undoubted professional qualifications and attainments now disqualified.

Resolutions were passed indorsing the Longworth bill providing for the licensing system on dye importations, and immediately forwarded to the Senate. Longer and more thorough courses in chemistry and engineering were recommended for technical students.

Because of the attractions provided by the entertainment committee headed by Mr. Frank N. Smalley, the sessions allotted for the reading of papers were not allowed to take their usual dominant position. The available time was used in reading selections which were then discussed. Space will not now be devoted to the details of this part of the program, as nearly all the manuscripts will be published in full at an early date, collectively in the semi-annual *Transactions* of the Institute and separately in subsequent issues of this and other journals. The addresses of the retiring and incoming presidents, Doctors Arthur D. Little and David Wesson, dealt especially with the South. The former will be published in full in a later issue, while the latter is given herewith, in part.

Notes on Excursions

The weather was favorable for the excursions, which were both pleasant and instructive. A motor trip to Bethesda (Wednesday), a steamer trip on the Savannah River with stopover at Port Wentworth's lumber mill, sulphate pine pulp mill and shipyard and at various warehouses along the route (Thursday), visits to the plants of the Southern Cotton Oil Co. and the American Agricultural Chemical Co. (Friday), all contributed to make these side lines of the annual meeting long to be remembered.



History and Development of the Cottonseed Oil Industry

By David Wesson

It seems particularly appropriate at this first meeting of the Institute of Chemical Engineers in a Southern city that an effort should be made to tell the story of how a great industry has been founded and built up on what was once a by-product and a nuisance.

The early records do not tell us much. We find in the statistics of South Carolina published in 1826 that Dr. Benjamin Waring established a mill at Columbia, S. C., and expressed from cottonseed a very good oil. Georgia had an oil mill in 1832, but little is known about it. C. D. Arfwedson, an English traveler, in his book entitled "The United States and Canada, 1832, 1833 and 1834," states, "In many places it is usual to manure the fields with the seed not used for planting, but of late years experience has taught the planters to set a higher price on it, as it contains a considerable quantity of oil which is extracted by pressure and is suitable both for burning and painting. The oil may in the course of years become an additional source of wealth to the planters."

Up to the time of the Civil War and in fact for some time after, the disposal of the seed was always more or less of a problem. Much of it was used for fertilizer, and a great deal of it was thrown into the water courses. In 1857 the State of Mississippi passed laws fining gin owners who allowed seed to accumulate at gins located near towns and villages, where it was apt to become a nuisance. The fine was $20 per day after the fifth day. Another law imposed a fine of $200 for throwing the seed into water courses the waters of which were used for drinking and fishing.

The industry began to assume some importance just prior to the Civil War, after which it commenced to grow. In 1860 there were seven factories employing 183 workers. In 1870 26 factories employed 644 workers, while today about 900 factories give employment to about 20,000 workers and 5000 officers and other salaried men.

The causes for the rapid growth of the industry are various.

First, the rapid increase of population all over the civilized world made increased demands for food. The doing away with the large cattle ranches of the West reduced the meat supply so that the hogs which formerly furnished an adequate supply of lard were more and more eaten as pork and a demand was made for an edible fat to replace the lard. This demand is largely met at this time by cottonseed oil and the growth of the cottonseed oil industry is largely coincident with the decrease per capita of the hog lard supply.

Second, the cottonseed oil produced in the early days of the industry was very irregular in quality. In 1879 it was used in small quantities to adulterate lard, but the quality was such that it did not improve the mixture. The application of chemistry to the industry at this time started it upon a rational basis and gave such a stimulus that it has grown by leaps and bounds ever since. The advent of the chemist started improvements in the quality of the oil and at the same time pointed the way to economies in production.

The most important work of the chemist has been in refining the oil and improving the products made therefrom. To do this principles had to be established in the laboratory and applied in the factory.

Early Refineries

The first crude oil was used for paint and burning in lamps. The early refineries kept their methods so secret that it has been difficult to discover when oil was first refined in this country. The writer remembers being told in 1870 that peanuts were pressed to obtain oil which was mixed with that of the cottonseed and sold for olive oil.

The early refineries were connected with the oil mills, but there soon arose people who recognized that refining the crude oil as furnished by the mills was an industry by itself and refineries started in several places.

The crude oil in the early '80s was sold on color and flavor and in case of disputes referred to committees. About this time the chemists discovered that free fatty acid in the crude oil was an index of quality and refining loss and applied the test in judging value of samples. A small-laboratory refining test was made to see if the samples of crude would refine to a good color. The writer used this method in Chicago in 1887 and when in 1890 he commenced to reject oil in New York on

account of high acidity he encountered much opposition, some mill owners protesting that they had never had any fatty acids on their premises.

Shortly after 1880 cottonseed oil began coming to Chicago in considerable quantities. Here it was refined with caustic soda, bleached with fuller's earth, mixed with prime steam lard and oleo stearine and went into commerce as refined lard. In 1887 it was discovered that more lard was shipped from Chicago than came there either on the hogs killed there or as lard itself. Congress started an investigation and discovered that cottonseed oil was the cause of this great increase. They also discovered that the 30 to 40 per cent of oil in the compounds did not injure them from a health standpoint, though the oil used at that time did not improve the flavor.

About 1892 or 1893 the practice of deodorizing was started in Chicago. This consisted in heating the oil in a tank provided with a large steam coil and then blowing live steam through the oil to remove flavor and odor. The oil was afterward cooled to normal temperature. This process, while producing a greatly improved oil, did not turn out a perfect one by any means. It allowed the lard substitute maker, however, to use a mixture of about 82 per cent oil and 18 per cent oleo stearine, which proved quite satisfactory to the trade.

The Wesson Process

In 1899 the "Wesson process," so called, was discovered and the first plant was put in operation in Savannah the following year. The product of this plant set a new standard for cottonseed oil, which has now become the chief source of edible fat next to butter in this country. From the discovery of the Wesson process to about 1910, lard substitutes were made almost entirely of mixtures of oleo stearine and deodorized cottonseed oil. The packer controlling the former put its price very high and the demand for a cheaper material was supplied by the discovery of the hydrogenation process which fulfilled the dream of the fats chemist by furnishing a ready means of saturating the double bonds of the fluid oils with hydrogen and converting olein and linolein to stearine. By passing hydrogen gas through oil at a temperature of 180 to 200 deg. C. in the presence of finely divided nickel, cottonseed oil can be hardened to any extent up to a melting point of about 60 deg. C.

The lard substitutes of the present day are almost entirely produced either by partly hardening the whole oil or by adding sufficient completely hardened oil to that which has not been so treated. Besides the use of the oil in lard substitutes, which utilizes at present about 75 per cent of the total production, large quantities are used for table oils, oleomargarine, or margarine, as it is called in Europe. Considerable oil is also used in medicine.

In refining the oil an average of 9 per cent is taken out by the alkali in the form of soap stock. In the early days this was made into cheap laundry and mill soaps. Later it was made into washing powder by first saponifying and washing, then mixing with soda ash or salsoda. At best the soaps made directly from the soap stock were poor in color and possessed an unpleasant odor. It is the practice in several large plants to decompose the soap stock with acid, then saponify by the Twitchell process or otherwise and distill the fatty acids from the black elastic pitch which remains. This pitch is used in making paints used for roofing. During the war considerable quantities of glycerine were recovered from the soap stock, but on account of changed conditions it has been found better to treat the soap stock with centrifugal machines of the cream separator type and recover a considerable quantity of the entrained neutral oil.

Early Crude Oil Mill Practice

The first crude oil mills were somewhat primitive compared with those of the present day. No attempt was made to separate the lint from the seed before passing through the hullers. In those days the seed carried so much lint it was customary to figure meats and hulls as equal in quantity. The early mills burned the hulls under the boilers together with the trash in the seed. The separation was very poor and the hulls frequently carried large quantities of uncut seed and meats which helped account for the high hull percentage.

The separated meats were crushed between rolls, cooked in jacketed heaters and pressed in box presses provided with thick camelshair mats between which the bags holding the meats were placed. The yield of oil was small, a large amount being left in the cake and lost with the meats which went into the hulls.

An important by-product of the old-time mills was hull ashes, which amounted to about 20 lb. per ton of hulls and were rich in potash and phosphoric acid. Actually the ash present was several times that recovered. On account of the character of the hulls much of the ash was carried up chimney. About 1887 it was found that the hulls could be used for fodder and cows have been eating them at increasing prices ever since. At the same time plat presses superseded the old boxes and better work was done in the press rooms. Linter or linter gins were also installed and the short fibers or lint was partly removed from the seed before hulling.

In 1887 the writer started a small laboratory in Chicago for analyzing mill products for the American Cotton Oil Co., which had just come into existence. The results on 244 samples of cake showed an average of 13.55 per cent oil, while 226 samples of meal averaged 12.18 per cent. Hulls were not analyzed, but inspected for meats and uncut seed. This was the beginning of mill control work in the industry. It has caused great economies and pointed the way to the use of better machinery. At the present time the meal runs from 6 to 7 per cent oil.

The cottonseed cake has always been either exported as such or ground into meal and used as a cattle food or fertilizer. One of the latest developments is the extraction of the oil from the cake and meal by solvents. At present prices this is a profitable industry. There is no good reason why solvent extraction should not be applied to the entire meats, cutting out the press-room expense and recovering 50 to 60 lb. of oil per ton of seed. If this were done it would have saved last year nearly 500,000 bbl. of oil, worth about $34,000,000. There is nothing to prevent this development except fear of fire risk and investment of capital. It is a comparatively simple engineering problem which many of us will doubtless live to see accomplished.

Owing to war conditions many oil-bearing materials and oils have been brought to this country and handled in the cotton oil mills and refineries. So great has been the variety and quantity of these different oils that it would seem more proper at the present time and in the future to talk of the vegetable industry.

Commercial Possibilities in the Electrochemical Production of Organic Compounds*

Description of Prospective Industrial Applications of Organic Electrochemistry — Advantages and Disadvantages Inherent in Electrochemical Methods — Conditions Favoring Economy in Operation, Catalytic Effect, Diaphragms—Some Suggested Organic Electrosyntheses—Status of the Industry

BY C. J. THATCHER, PH.D.

WE ALL know that, in industrial applications at least, the electrochemistry of the organic compounds has not kept pace with the progress in other lines of electrochemical activity. Probably most of us would have difficulty in naming more than a few organic compounds which have been successfully manufactured by electrochemical methods, at least in this country. Indeed, progress in this direction has been so restricted that there has been, or seems to be, hardly any interest in this branch of the electrochemical industry.

It is true that in February, 1915, this Society held a symposium consisting of three papers on the subject of organic electrochemical manufacturing, followed by a discussion in which a number of members took part. Both optimistic and pessimistic opinions regarding the future were expressed in the papers and discussions. Whatever may have been the general consensus of opinion, it is certain that the symposium did not cause any noticeable activity in the electrochemical production of the carbon compounds despite the apparently favorable opportunity presented by the war. At that time I myself was preparing to manufacture and have since manufactured, electrochemically, several tons of paramidophenol sulphate—an intermediate and a photographic developer—and have also since then made anthraquinone and hydroquinone on a small-factory scale; but no other serious attempts to establish organic electrochemical operations during the war now ended have come to my attention.

Perhaps the period intervening since that symposium has not been the most propitious; for old and established processes were almost certain to bring needed and highly profitable results, and there was little or no time for laboratory or plant experimentation. However, that period is now passed, and enterprising American manufacturers are again confronted with the necessity for improvement and economy in production, in order that they may keep ahead of domestic and foreign competition.

PROSPECTIVE INDUSTRIAL APPLICATIONS OF ORGANIC ELECTROCHEMISTRY

Since it is in the new and comparatively favored field of dyestuff and other organic products that industrial preparedness against foreign competition will be most necessary, it would seem that we electrochemists should now seriously consider, with an open mind, whether we cannot blaze a path in this as we have in other directions. We do not need to be reminded that Yankee optimism, courage and ingenuity have, when once aroused, turned failures into successes, and confounded the wise in other countries. Our friends the enemy—in war as in chemistry—have had recent surprises along that line in the Argonne and elsewhere.

Now we have not really tried to manufacture organic derivatives here electrochemically. There is much that we do not know about what has been done or tried in other countries, particularly in Germany. But the mere fact—if it be a fact—that others have tried or failed does not conclusively prove anything as to what the American electrochemist can do.

The real question, which we ought to consider in all seriousness, is whether now and in this country are not the time and place to begin more or less extensive industrial applications of organic electrochemistry. To awaken some sustained interest, consideration and discussion of this question in this or other meetings is the object of my paper, and for this purpose I would ask you to consider, first, the basic principles which may indicate the kind of electrochemical operation which could be expected to be successful commercially; and thereafter to briefly consider specific electrochemical processes.

ECONOMIC BASIS OF ORGANIC ELECTROCHEMISTRY

To this end we may inquire first as to how economic values are created by industrial electrochemistry. That is a question which Dr. Roeber considered in his presidential address before this Society in April, 1914, and it seems well to apply some of Dr. Roeber's considerations to the subject of this paper.

Economic values are created by industrial electrochemistry—as in other similar lines of activity—either as time value, place value, or form value. Time or place value of organic electrochemical products is mainly due to their high energy content, which can be imparted to them more economically by the electric current. Such products are valuable mainly because they enable us to transmit their stored energy to another time or place. Calcium carbide and aluminum when used in aluminothermic reactions are examples of electrochemical products having a high time and place value. Their potential energy becomes kinetic whenever or wherever desired. These and other products of electrochemical industries acquire their economic value by serving as a medium for electrochemical power transmission. Many or most of this class of products are made by electrothermic methods.

But another and important class of electrochemical products has nothing to do with chemical power transmission. These are products which have a high form value, i. e., those which derive their intrinsic value from the mechanical and chemical work expended and dissipated in transforming the raw materials into the de-

*Read at the Chicago meeting of the American Electrochemical Society, Sept. 26, 1919.

sired finished product. Qualities other than a high specific content of energy impart the economic value to this class of compounds. Caustic soda, bleaching powder and electrolytically refined copper are examples. Such products are made by electrolysis, for the most part; they have a high form value due to the work expended during electrolysis upon comparatively cheap raw material. In the production of nitric acid or nitrates by atmospheric fixation, the raw material, air, is more than cheap, it has no economic value, we may say. Therefore the form value of nitric acid and nitrates so produced is unusually high.

On the basis of past experience, and reasoning by analogy, we may conclude, therefore, that products which have a high form value are such as stand the best chance of being economically produced by electrolytic methods. The comparatively wide margin between the value of the raw material and the finished product permits a considerable saving whenever electrolytic methods reduce the cost of the mechanical and chemical work put into the operation. This comparatively large saving often more than offsets the interest and other charges due to the design and construction of electrochemical equipment.

This somewhat abstruse consideration has a very practical bearing upon the subject of this paper, for it will help to decide whether electrochemical methods of production may be expected to be economical in the manufacture of organic compounds, and it should enable us to tackle the problem along the lines of least resistance. Electrothermic methods are almost but not quite excluded in the manufacture of the carbon compounds. It is in the technical applications of electrolysis that electrochemical operations should succeed if at all. And our prior consideration teaches that a very large number of organic compounds should be capable of being produced electrochemically, because of the vast number of organic compounds which have a high form value. The carbon compounds (particularly the aromatic compounds, such as dyestuffs) have a high form value, more so than inorganic compounds as a class. The average high value of such compounds is not due to a high energy content, nor to the value of the organic raw material, which is often comparatively low. Their value is due, rather, to the amount of manual, mechanical and chemical energy expended and dissipated in transforming the relatively cheap raw materials or intermediate into pure, finished product. And we have seen that just such transformations are a most promising field for industrial electrolytic operations.

We are forced to conclude, therefore, that the basic economic principles are favorable for the profitable production, by electrochemical methods, of a very large number of organic chemicals—all such as have a high form value.

Advantages Which May Inhere in Electrochemical Methods

Obviously, in the final analysis, electrochemical methods are advantageous only when they are more economical. But economy may be due to several causes. We will consider only the production of known products already in demand, and now produced by chemical methods, and not new compounds which the characteristics of the electrode processes might enable us to produce.

Electrochemical methods may supplant chemical methods:

First: When the same organic raw material is used.

(*a*) By increasing the yield through control of conditions to be later considered.

(*b*) By eliminating inorganic raw materials such as oxidizing or reducing agents, as by substituting electrolytically generated oxygen and hydrogen.

(*c*) By electrolytic regeneration of inorganic raw materials, as for example spent chromic acid liquors.

Calculation will show that with but few exceptions, it is cheaper to oxidize, reduce or substitute by electrolytic than by chemical means, a fact which was brought out by Mr. Lidbury in the symposium previously referred to[1].

This is particularly true when, as is sometimes possible, both the anode and cathode reactions may be made to perform useful work, either in the preparation of the same or different organic products.

But even without such possible economy, electrochemical transformations, figured on an equivalent basis, are usually surprisingly cheaper. For example, with power at metropolitan rates, it costs about ten times as much to oxidize with bichromate as at the anode of a well designed cell. And if an electrolytic oxidation saves 35c. per lb. buying power at metropolitan rates, it is not necessary and may not pay to locate the plant in an inaccessible locality in order to use hydro-electric power at an additional saving of only a few cents per pound.

Whenever, therefore, electrolytic oxygen, hydrogen, chlorine, etc., give as good a yield per unit of organic raw material, we have every reason to expect economy. For any increased charges, inherent in the use of electrolytic equipment, such as interest and depreciation, need not, if the cell is properly designed, be enough nearly to eliminate the economy in favor of the electrolytic method.

There are numerous organic compounds now prepared chemically by oxidation, reduction or substitution, which, by skillful control of conditions in a properly designed cell, can be more economically made electrochemically from the same raw materials as those now used, for one or more of the reasons specified above. Only poor yields, excessive depreciation, etc., can prevent success, and it will be shown that improvement in these particulars can be effected.

Secondly: When a cheaper organic raw material may be used.

It would carry us beyond the scope of this paper to consider the various instances in which such a substitution may be made. Briefly stated, the conditions obtaining at the surface of an electrode are much more variable and controllable than in purely chemical transformations, so that new reactions can be used technically, or a number of intermediate steps may be combined into one operation.

One of the features of electrode processes which accounts for the economy thereby effected is the wide range of gas pressure obtainable at the surface of an electrode by suitable variation of the electrode potential. Referring to this point, Prof. Nernst stated[2] that it was possible to liberate a gas, such as chlorine, at the anode either in greater than homeopathic dilution or at

[1] Met. & Chem. Eng., vol. 13, No. 4, p. 211; April, 1915.
[2] Berichte, 1897, p. 1562.

pressures which amount to millions of atmospheres, and that this vast range of pressure made it possible to readily chlorinate organic compounds to every conceivable degree. The importance of the regulation of gas pressure in organic synthesis has been shown in many hundreds of instances. Thus, in organic substitution processes, the number of substituted atoms is often dependent upon the pressure at which the reaction occurs. Since any desired pressure can be so conveniently created, and maintained at an electrode, solely by variation in electrode potential, it is obvious that electrochemical methods should frequently be more direct and economical. As Prof. Haber once stated:

"Whereas the nucleus of the aromatic compound is not attacked by most chemical oxidizing materials, or is completely destroyed, accompanied by the disruption of the ring, electrolysis under favorable conditions permits a smooth oxidation, with the result that the hydroxyl group is introduced into the benzol nucleus. Benzol is thus oxidized in sulphuric acid solution at the anode to hydroquinone, aniline to paramidophenol, azobenzol to tetraoxybenzol, anthracene to alizarine."

No explanation of the economy resulting from such direct syntheses of coal-tar crudes is needed.

Thirdly: When a high degree of purity is desirable. We can oxidize or reduce by electrical energy without contaminating the finished product by foreign materials the complete removal of which is generally troublesome and expensive.

The three general considerations above outlined should be sufficient to show why it will be advantageous and economical to use electrochemical methods in manufacturing organic compounds. And we have also seen that the use of such methods may be expected to be successful in the manufacture of products having a high form value. Let us consider the other side briefly.

Disadvantages Which May Inhere in Electrochemical Methods

The objections to the commercial use of electrochemical methods in preparing organic compounds were very concisely stated at the symposium in 1915, by Mr. Lidbury, in the following words:

"In the first place, to do a unit of chemical work in a unit of time, the electrolytic plant would be usually very much larger than a chemical plant; require very much more room; be usually very much more expensive; require more expert attention, and on account of the extreme severity of the demands of electrolytic methods on materials employed for plant, etc., the upkeep would usually be higher.

"In the second place, the working out of an electrolytic method requires a very much greater amount of time, thought, intelligence and expenditure than the working out of a chemical method. Though this might not amount to much as regards laboratory investigation, anyone acquainted with the electrochemical industry would be aware of the greater difficulties which invariably have to be overcome in preparing such a process for large-scale operation, and in that important phase known as 'establishing practice.'"

I am not sure that we can all agree as to the validity of the first of these objections. However, is it not a fact that such objections could be raised against the adoption of any electrolytic process, inorganic as well as organic? It would seem that almost any electrochemical plant is necessarily larger and is more expensive to design, construct, establish, practice and maintain. We cannot deny the commercial practicability of organic electrolytic plants upon grounds which would deny the practicability of existing successful electrolytic plants. Wherever, for reasons already given, there is any considerable economy of operation in electrolytic methods, higher interest charges due to greater expense in the design, equipment and maintenance of an electrolytic plant are more than offset, at least in any plant producing annually 100,000 lb. or more of an organic product.

Conditions Favoring Economy in Operation

Electrochemical methods of production are, of course, only economical when operated under skillfully selected and controlled conditions. It is not my purpose to consider such conditions at any great length in this paper. They include electrode material, chemical and electrical conditions, catalytic effects and diaphragm material. Excepting the latter two the complexity and range of variation are too great to be considered advantageously in any general manner. But it will be worth while to consider briefly factors capable of a more general consideration, such as catalytic effects and the use and nature of diaphragms.

Catalytic Effects

The nature and importance of catalytic action upon electrode processes were set forth by Prof. Ostwald with customary insight in his paper presented at the International Electrical Congress at St. Louis in 1904[1]. A few quotations from this paper will be most instructive. Prof. Ostwald stated:

"If there are several possibilities for the reaction at one electrode, the readily occurring chemical reaction depends not only on the nature of the possible chemical reactions, but upon the concentration of the substances which are present, and by suitably varying the latter we can bring any reaction to any point in the voltage series."

"In connection with this it should be emphasized that what is called briefly *'the electrode process'* is in reality a rather complex phenomenon."

"It will thus be seen that even the simplest electrode reactions are made up of a plurality of reactions following each other step by step. Since each of the same can be influenced catalytically, it is already evident that a very great variety of results is possible."

"Such means of changing the speed of a given reaction within very wide limits exists really in chemistry in what is called *catalyzers*. Herefrom it is at once evident which very important and essential part the catalyzers are able to play in electrolytic action. By retarding one of the possible reactions by means of a negative or retarding catalyzer, we are able to *exclude* its influence from the electrolytic process. By accelerating by means of a catalyzer a reaction which is of itself slow, we can *include* it into the electrolytic process. In other words, we are no longer compelled to let the current act in the way stated by the above simple law, but in principle we are now able, *by applying suitable catalyzers, to prescribe to the current that reaction which we want to take place*, and it does not matter at which point in the voltage series this reaction is situ-

[1] *Electrochemical Industry* (Now Met. & Chem. Eng.), vol. 2, No. 10, p. 393; October, 1904.

ated. This fundamental idea may be applied in two directions. First, in synthetic work; if we suppress by negative catalyzers those reactions which would take place before the desired one, we can bring the desired reaction to the front, or if the reactions which take place before the desired one take place with a low speed, we can accelerate the speed of the desired reaction by means of a positive catalyzer and can thus produce the same effect. The second application is *for analyzing the reactions which really take place at the electrodes.*"

The improvements which may be effected in industrial organic syntheses by suitable control of catalytic action is sufficiently outlined for present purposes in the foregoing. A more detailed consideration of the subject will be found in Prof. Ostwald's paper, in President Bancroft's recent address on "Poisoning of Catalytic Agents"[4], and in papers[5] describing my investigations in Prof. Ostwald's laboratories which called his attention to the subject.

Use and Nature of Diaphragms

It is probable that the need of suitable diaphragms for an electrolytic cell for the manufacture of organic compounds has hindered the development of the industry as much as or more than any other factor. On account of the nature of organic compounds, many of which are either insoluble or non-electrolytes, it is usually necessary to employ a solvent electrolyte, which tends to disintegrate diaphragms so rapidly as to prohibit commercial operations. Few materials suitable for diaphragms will withstand the corrosive effect of strong acids, alkalis or oxidizing liquids for any length of time. Other materials which might be more resistant become clogged during use, accompanied by a prohibitive increase in resistance.

I encountered such difficulties at the outset of my own organic electrochemical manufacturing, and was obliged to devise a diaphragm suitable for the purpose. This diaphragm, known as Electro-Filtros, has been in commercial use in organic electrochemical operations since 1915; and experience has shown that it is absolutely permanent in acid and neutral solutions and adapted to the purpose. It is described in Metallurgical & Chemical Engineering, May, 1915, pages 336-338, and is manufactured and sold by the General Filtration Co. It is not suitable for use in strong alkalis; but organic electrolytic operations involving the use of any other kind of solvent need not be unsuccessful through lack of a suitable diaphragm.

Some Suggested Organic Electrosyntheses

Approximately 150 patents have been granted, most of them prior to 1910, for electrochemical processes producing organic compounds. The bulk of these are German patents, which fact alone tends to indicate the interest in Germany in this line. A list of a few of these and other suggested organic compounds will be sufficient for the purpose of this paper; but in preparing the list it has not been restricted to preparations of known or proved commercial practicability.

With this understanding it might be said that the following offer some possibilities: Alcohols, aldehydes and ketones of fatty acids, iodoform, vanillin, chloral, azo and hydrazo compounds, oxidation products of fusel oils, dyestuffs of the triphenylmethane type, aniline blue, aniline black, Hofmann's violet, anthraquinone, alizarine, congo red, orange II, sulpho acids, piperidine, dihydroquinoline, benzidine, amidophenol, chlorbenzols, quinone, hydroquinone, saccharine and phthalic acid.

Status of the Industry

The technology of organic electrochemistry has, of course, reached its greatest development in Germany, as a natural consequence of Germany's attention to the organic field. The great secrecy maintained there in this line has made it impossible to obtain exact knowledge regarding the status of the industry. It has been stated on good authority that chloral, vanillin, iodoform, azo and hydrazo compounds have been profitably manufactured electrochemically and that one concern at least was, prior to the war, operating a large electrochemical plant devoted to the production of anthraquinone.

In Switzerland, according to my information, at least one electrolytic plant has been engaged in the production of chloroform, chloral and phosphorous chlorides, and has been utilizing electrolytic chlorine in the manufacture of synthetic indigo.

If there have been any extensive developments in this country they have escaped my attention, excepting the use of electrolytic chlorine for the indirect production of monochlorbenzol and dichlorbenzol and similar organic compounds. As already stated, I myself have made several tons of photographic developers electrochemically in the last few years and have produced hydroquinone and anthraquinone on a small-factory scale.

One of the greatest obstacles to the progress of the industry has been the scepticism of manufacturers and financiers regarding the possibilities. That, however, is nothing unusual, for it was not many years ago that the manufacture of steel in the electric furnace was ridiculed by both manufacturers and technologists. The next ten years or so will witness a development of the organic electrochemical industry which will surprise many, for, as has been shown in this paper, the underlying economic principles are favorable.

[4] *Trans.*, A. E. S., vol. 32 (1917) pp. 459-462.

[5] *Zeit. f. Phys. Chem.*, vol. 45, pp. 225-230; vol. 47 (1909), p. 687; *Electrochemical Industry* (Now Met. & Chem. Eng.), 1904, pp. 452-454.

Cotton Consumption During Fiscal Years 1918 and 1919

The consumption of cotton during the year ended July 31, 1919, was 5,767,519 bales, against 6,566,489 bales during the previous year. Linters consumed amounted to 455,337 bales in 1919 and 1,118,840 bales in 1918.

Imports of foreign cotton during July were 19,403 bales of 500 lb. in 1919 and 25,002 bales in 1918. Imports for the year ended July 31 reached 201,586 bales in 1919 and 221,216 bales in 1918.

The exports of domestic cotton and linters during July, 1919, amounted to 528,902 bales, against 218,877 bales in July, 1918. The total export for the twelve months ended July 31, 1919, was 5,605,736 bales, against 4,476,124 bales for the previous year. These figures include 1879 bales of linters exported during July in 1919 and 16,802 bales in 1918 and 71,534 bales for the year ended July 31 in 1919 and 187,704 bales in 1918.—*Fortnightly Information Review, Nov. 1, 1919.*

Stretched Wire Apparatus for Measuring Thermal Expansions

By Arthur W. Gray

DETERMINATIONS of linear thermal expansivity involve:

(1) Production of temperature uniformity.
(2) Determination of temperature.
(3) Measurement of small length changes.

Of these, the last is by far the most difficult.

Difficulties in Making Reliable Measurements

The difficulties that arise in connection with the measurement of length changes are of two kinds:

First, the displacements are generally so small that in order to attain even moderate percentage accuracy, high absolute accuracy is necessary. It is comparatively easy to arrange devices of sensitivity sufficient to indicate displacements smaller than one-tenth of a micron; but it is not quite so easy to attain such precision upon repeated attempts to measure the same length. It is not at all easy to make sure that such precision, when attained, represents real accuracy, that is to say, correctness.

In the second place, measurements of thermal expansions are far more difficult than ordinary length measurements requiring the same degree of accuracy. The very nature of the case demands that the body under investigation be measured at several different temperatures; and changes of temperature are always accompanied by displacements in various parts of the measuring apparatus. Unless special precautions are taken, these displacements give rise to errors which are always difficult, and often quite impossible, to determine with certainty. So-called compensating devices are generally unreliable. Rather than trust them when accuracy is of importance, it is better to design apparatus which will render the errors negligible, or at least will make them determinable with certainty.

It was for the reasons just given that the writer introduced the use of stretched wires in 1911 when designing for the Bureau of Standards the equipment still used in determining the thermal expansivity of materials in the form of bars.

Stretched Wire Method for Measuring Linear Displacements

With the aid of such a simple device as a tightly stretched fine wire it is fairly easy to measure with great accuracy a displacement which occurs within a region otherwise difficult of access.[1]

Apparatus on this principle has been employed for the past eight years in the determination of thermal expansions. Two such arrangements of stretched wires are represented diagrammatically by Figs. 1 and 2. In each the expanding bar is indicated by *AB*. In Fig. 1, wires are freely suspended in contact with the ends of the bar and are stretched vertically by the weight of vanes immersed in oil, the viscosity of which is adjusted to damp any swinging of the wires so that their motions will be almost, but not quite, aperiodic. In Fig. 2, suitable for cases in which the bar is immersed in a liquid, wires are stretched upward to another bar *CD* rigidly connected with the central portion of *AB*. In both arrangements the transverse motions of the wires are observed through micrometer microscopes focused at convenient points *E* and *F*. Disturbances from changes in level are avoided by grinding ends of *AB* to form portions of a horizontal cylinder, the axis of which passes through the center of the bar.

Accuracy and Range of the Method

Unless one has had actual experience with this method of rendering displacements accessible to measurement, it is difficult to believe the accuracy attainable when proper precautions are taken. Thousands of observations have convinced me that the method is the most reliable yet devised for the measurement of thermal

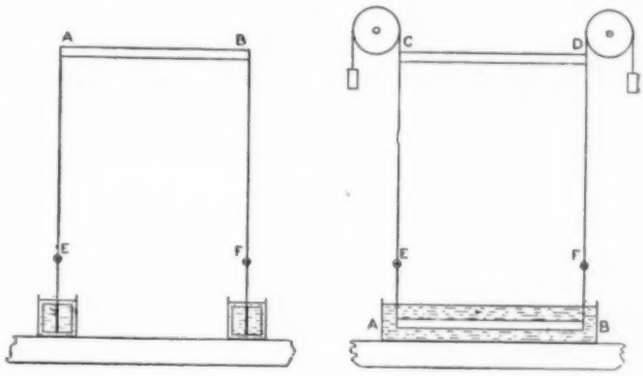


FIG. 1 & 2. DIAGRAM OF STRETCHED WIRE DILATOMETER

expansions. I have used the arrangement of Fig. 2 in an oil bath maintained at any desired temperature from near —150 deg. C. up to +350 deg. C., and I have used the arrangement of Fig. 1 in an electric furnace at various temperatures up to about 650 deg. C. I have not personally tested the method at temperatures much above 650 deg. C. Sufficiently fine wires of nichrome or other non-oxidizable material strong enough at higher temperatures to sustain the weights of the damping vanes were not obtainable while I was at the Bureau of Standards. Nor were my arrangements completed for an atmosphere within the furnace which would permit the use of tungsten wires. Recently, however, Dr. Souder, who is now in charge of the Expansion Laboratory, informed me that the Bureau had obtained fine enough wires of a nickel-chromium alloy which, even in air, remained sufficiently strong at temperatures up to 1000 deg. C. Tungsten, if protected from oxidation, could probably be used up to 1400 deg. C., or perhaps even higher.[2]

The stretched wire method of measuring expansions has not yet been tried at temperatures below —150 deg. C., because suitable temperature baths have not been conveniently available. The pentane which was used for the bath liquid becomes so viscous when cooled to near —150 deg. C. that proper circulation is no longer possible. It would, however, be a simple

[1] Expansion measurements by this method were reported to the American Physical Society at the Washington meeting in December, 1911, and at various times since then. (A. W. Gray: "A New Type of Apparatus for Measuring Linear Expansion," *Phys. Rev.*, vol. 34, p. 139, 1912.) The principle of the method was also described in a communication to the Washington Academy of Sciences. ("New Methods for Displacement Measurements and Temperature Uniformity Applied to the Determination of Linear Expansivity," *Journ.*, Wash. Acad. Sc., vol. 2, p. 248, 1912.) See also "Production of Temperature Uniformity in an Electric Furnace," Bull. Bureau of Standards, vol. 10, p. 451, 1914; Scientific Paper No. 219.

[2] Jeffries recently found the equi-cohesive temperature of platinum to lie between 525 and 550 deg. C. This explains why I could not get platinum wire to sustain continuously the weights of even very light damping vanes when the temperature rose much above 600 deg. C. Jeffries found the equi-cohesive temperature of tungsten to be about 1350 deg. C. (Zay Jeffries: "The Amorphous Metal Hypothesis and Equi-Cohesive Temperatures," *Journ.*, Am. Inst. Metals, vol. 11, pp. 300-323, 1917.)

matter to modify the apparatus so as to use a bath of liquid air; and, with such refrigerating facilities as are available in the Cryogenic Laboratory of Kamerlingh Onnes, the wire method could be used down to the very lowest temperatures producible with the aid of liquefied helium. It is merely a question of sufficient refrigeration and a suitable container for the bath.

The complete equipment which I planned for the Bureau of Standards has never been finished, and consequently has not been described; but some accounts of measurements made with this apparatus at various temperatures ranging from below —140 deg. C. to above 600 deg. C. have recently been published by my former assistants Schad and Hidnert, by Merica and Schad, and by Price and Davidson.[3]

The data contained in these papers, some of which are presented graphically, illustrate the performance

FIG. 3.
DILATOMETER WITHOUT HEATING BATH

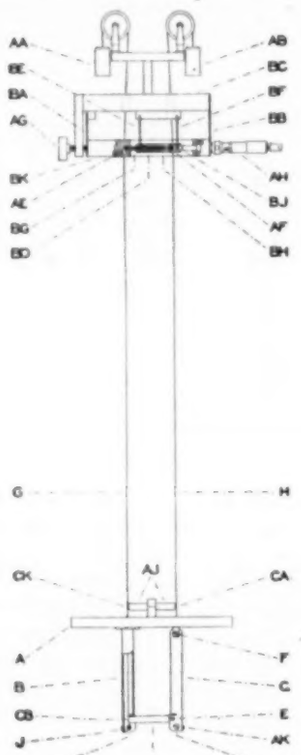


FIG. 4. SKETCH OF ESSENTIAL PARTS OF DILATOMETER

of stretched wire expansion apparatus under conditions of ordinary routine tests. The precision is most clearly shown by Schad's and Hidnert's measurements of the expansivity of molybdenum. They found that all their length observations made at temperatures ranging from —142.5 deg. to +18.7 deg. C. were expressible by a quadratic equation with such precision that the probable error of a single observation was ±2.6 microns per meter. Likewise, the probable error of a single observation on heating from 18.7 to 305.3 deg. C. was found to be ±2.5 microns per meter. Since the specimen tested was only 20 cm. long, these values indicate that the probable error in making a single expansion measurement was about ±0.5 micron. Moreover, a second set of observations from room temperature to 304 deg. C., taken several days later, yielded an equation which agreed so closely with that obtained during the first test that the lengths determined from the two equations did not differ by more than 4 microns per meter, or 0.8 micron in the length actually measured. Some of the slight differences observable between heating and cooling curves, and between curves obtained from different tests of the same specimen, are due to the fact that no solid has yet been found which assumes exactly the same dimensions every time it is brought to the same temperature. Molybdenum repeats better than most substances, and is, therefore, well suited for ex-

expansion apparatus is also well illustrated by the

is useful not only for adjusting observations, but also be seen by examining the deviation curves published by Merica and Schad.[4]

Simple Stretched Wire Dilatometer

While the equipment developed at the Bureau of Standards is very efficient for the accurate investigation of thermal expansivity over a wide temperature range, it is more elaborate than is necessary for most scientific or industrial purposes. A simple but reliable dilatometer which the writer made from material to be found in almost any physical laboratory may therefore be of sufficient interest to warrant a more detailed description than that already published.[5] The apparatus, which uses the stretched wire method of measuring linear displacements, could easily be adapted for commercial testing. It differs from the precision apparatus at the Bureau of Standards mainly in the substitution of an ordinary Brown & Sharpe micrometer screw for the expensive microscope comparator and reference bar. Fig. 3 is a photograph of the dilatometer without the oil-bath for heating the specimen under test. Fig. 4 is a somewhat diagrammatic vertical projection partly in section. Minor constructional details are not represented in order that the essentials may stand out more clearly.

Detailed Description of Simplified Apparatus

Extending vertically downward from the cover *A* of the temperature bath made of asbestos wood are two tubes *B* and *C*, the axes of which are separated by approximately the length of the specimen *D*. At the

[3] L. W. Schad and Peter Hidnert: "Preliminary Determination of the Thermal Expansion of Molybdenum," Bull. Bur. Standards, vol. 15, pp. 31-40, 1919. P. D. Merica and L. W. Schad: "Thermal Expansion of Alpha and of Beta Brass between 0 and 600 deg. C., in Relation to the Mechanical Properties of Heterogeneous Brasses of the Muntz Metal Type," *Journ.*, Am. Inst. Metals, vol. 11, pp. 396-407, 1917; Bull. Bur. Standards, vol. 14, pp. 571-590, 1918. W. B. Price and Philip Davidson: "Physical Tests on Common High Brass Taken Parallel and at Right Angles to the Direction of Rolling-Appendix," *Trans.*, Am. Inst. Metals, vol. 10, 1916.

The expansion determinations reported by Price and Davidson were planned in detail by the present writer; the measurements and charts were made by Messrs. Schad and Hidnert; the specimens of brass were furnished by Mr. Price.

[4] In specifying the accuracy of the method, Merica and Schad (*Journ.*, Am. Inst. Metals, vol. 11, 1917, p. 399; Bull. Bur. Stand., vol. 14, 1918, p. 577) state: "The length changes measured in this way are accurate to about ± 0.001 mm., which on a specimen of 300 mm. long (the standard length of the specimen) would be ± 0.0003 per cent." The last part of this statement, however, is misleading, because percentage accuracy in expansion measurements should be expressed as a certain per cent not of the length of the specimen, but of the elongation measured. This will depend not only upon the accuracy of the apparatus and upon the length of the specimen, but also upon the expansivity of the latter and upon the temperature range employed. Since apparatus using a given method of determining thermal expansivity can usually be constructed to accommodate specimens of any convenient length, the essential elements that should enter into a description of the accuracy obtainable by a particular type of apparatus are absolute accuracy in the measurement of elongations and absolute accuracy in the production and the determination of uniform temperatures.

[5] Abstract of a paper presented at the Baltimore meeting of the American Physical Society. *Phys. Rev.* vol. 13, p. 142, 1919.

lower end of each tube are two pointed co-axial screws *E* for clamping *D* from opposite sides. One of the tubes, *B*, is rigidly attached to the cover *A;* the other, *C*, is hinged at *F* so as to permit free expansion of the specimen. Fine wires, *G* and *H*, of annealed tungsten, clamped to the lower ends of the tubes by means of the screws *J* and *AK*, extend vertically upward through the tubes and the cover for several decimeters above the latter, where they pass over pulleys and support weights *AA* and *AB*, which keep them tight and straight. The pins *AC* and *AD* cause the wires to bear firmly against the rounded ends of the specimen *D*. Small circumferential V-grooves in these pins center the wires and prevent them from slipping across the ends of the specimen.

At the upper end of the apparatus are two smooth round pins *AE* and *AF*, which bear against the wires *G* and *H*, a decimeter or so below the pulleys. By means of the screws *AG* and *AH* these pins move horizontally in the plane of the wires, so that the upper portions of these wires can be brought closer together or separated a measured distance.

Just above the cover of the temperature bath is placed a horizontal bar *AJ*, of low and known thermal expansivity, protected as far as possible from temperature changes accompanying warming and cooling of the bath below.

This bath, which is not shown in the illustrations, is of oil, heated electrically, and continuously stirred by a screw propeller, the containing tank being provided with suitable guides for insuring thorough mixing and circulation. If air is excluded to prevent flashing, "Renown" engine oil can be used to over 300 deg. C. Pentane gasoline remains sufficiently fluid down to about —150 deg. C. Although these two liquids will cover the entire range, kerosene is usually the most convenient substance when measurements do not have to be extended much beyond either 0 deg. or 75 deg.

After the specimen has been placed in the heating bath and temperature equilibrium has been reached, the upper end of each stretched wire is moved until the wire just touches the end of the bar *AJ*. Contact is indicated electrically by means of an inexpensive reflecting galvanometer in series with a dry cell and a suitable resistance. As the specimen *D* expands, it moves the wires away from the contact bar *AJ*. The magnitude of the expansion is determined from the movements of the screws *AG* and *AH* required to restore contact.

Only one graduated screw is actually used. The ordinary screw *AG*, of moderately fine pitch, moves a horizontal bar *BK*, to which are rigidly attached both the pin *AE*, which communicates the motion to the left-hand wire *G*, and the nut of the graduated screw *AH*, which moves the right-hand wire *H*. In this way a single micrometer screw is made to measure the total displacement of both wires. A Brown & Sharpe micrometer head is convenient for this purpose.

The movement of the bar *BK* is guided without lost motion by means of the thin flat strips of spring metal *BA* and *BB*, which suspend it from the bar *BC*. The smaller bar *BD*, which carries the pin *AF*, is likewise supported by the flexible strips *BE* and *BF* so that it is freely movable horizontally within a rectangular cavity cut through the central portion of *BK*. The spiral spring *BG* surrounding the rod *BH* presses *BD* firmly against the end of the measuring screw *AH*. The steel ball *BJ*, pressed tightly into the end of *BD*, makes an excellent bearing for the end of the screw.

The bar *AJ* is merely a piece of Pyrex glass tubing. (Fused quartz, because of its still smaller thermal expansivity, would be better.) Bearing firmly against each end of the tube, a tungsten wire (*CK* and *CA*) about 0.1 mm. in diameter is tightly stretched horizontally between two posts, one of which serves to connect the wire electrically with the galvanometer for detecting contact with the adjacent vertically stretched measuring wire. These posts, which may be ordinary machine screws with nuts, are not represented in Fig. 4, but are visible in Fig. 3. The ends of the tube are, of course, suitably ground so that the horizontal wires will be parallel to each other, and so that there will be no interference with the motions of the vertical wires. The horizontal wires define the effective length of the contact bar *AJ*.

Preparation of Specimens for Testing

The preparation of a specimen for an expansivity determination is an easy matter. All that is necessary is to cut off a rod of the required length and to round the ends smoothly, so that they form portions of a cylindrical surface. The rounding should, however, be accurately done, since its purpose is to prevent small angular displacements in the plane of the wires, causing errors by changing the distance between contacts. The easiest and best way of producing the cylindrical surfaces is by grinding.

Fig. 5 illustrates a simple tool for holding a specimen during this operation. By means of radial screws near each end the rod is firmly clamped within a metal tube. Midway between its ends this tube is pivoted between two co-axial pointed screws which hold it with-

FIG. 5. FIXTURE FOR GRINDING TEST SPECIMEN

in the arms of a forked bar of rectangular cross-section. As the bar is gradually advanced toward the edge of the grinding wheel, the tube containing the specimen is rotated between the pivot screws of the fork.

A screw-operated slide-rest is not at all necessary for feeding the specimen toward the grinding wheel. With the exercise of a little care the movement can be sufficiently well guided by pressing one corner of the forked bar into the dihedral angle of a support formed by fastening a straight strip of wood or metal upon a flat surface. The bar is advanced toward the wheel by gentle tapping against the farther end. Even glass can be ground in this way without difficulty.

Near each end of the tube which holds the specimen during grinding are two small holes, one from each side. These form convenient guides for drilling the little conical depressions or holes (*CB*, Fig. 4) that receive the pointed ends of the clamping screws *E*.

Sources of Error

The accuracy of the simple dilatometer described

above is limited mainly by the accuracy with which contact can be detected between the stretched wires and the bar *AJ* above the temperature bath. Immediately before taking a series of readings the contact surfaces of both the wires and the bar should be washed with a little ether applied by means of a camel's hair brush. With delicate touch the left-hand screw *AG* is then cautiously and steadily turned until the galvanometer gives the first slight indication of contact between the wire *G* and the end of the contact bar *AJ*. A small deflection that increases with continued advance of the screw indicates a better contact than a sudden, large deflection. After contact has been established with the left-hand wire, the measuring screw *AH* is advanced until the right-hand wire *H* makes contact with *AJ*. At each temperature or measurement, settings of both screws should be repeated a sufficient number of times to make sure that good contacts are being obtained. Failure to obtain a series of concordant readings is evidence that something is wrong—probably a dirty contact or lack of care in turning one of the screws.

The effect of errors in the measuring screw varies inversely as the ratio of the distances from the contact bar *AJ* to the pins *AE* and *AF* for moving the wires and to the specimen *D*. In the apparatus actually used these pins were 600 mm. above and the specimen 150 mm. below the bar, so that the micrometer screw *AH* measured four times the expansion of the specimen. The results showed that with proper use deviations of individual screw readings from the average should not exceed 5 microns. The average deviation of 107 individual readings from the average reading for each temperature was less than 2 microns, corresponding to an average deviation of 0.5 micron in determining the expansion of the specimen.

Corrections must be applied on account of length changes in *AJ* and in *BK* brought about by temperature changes occurring in these bars during the course of an expansivity determination. With a dilatometer in which the wires multiply the elongations by 4, the apparent expansion of the specimen must be corrected by the expansion of *AJ* and ¼ the expansion of *BK*. Although it is easy to calculate these corrections if the expansivities and the temperatures of *AJ* and *BK* are known, it is more convenient to render the corrections negligible, or at least very small, both by using materials of low expansivity for these parts of the apparatus and by protecting them from temperature changes—especially changes caused by convection, conduction and radiation from the bath for heating the specimen under test.

Concrete Illustration of an Expansive Determination

A concrete example illustrating the capabilities of the above-described simple apparatus is afforded by a determination of the thermal expansivity of some optical glass.*

A summary of the measurements made is contained in the accompanying table. In this table Column A gives in degrees Centigrade the temperatures of the oil bath in which the specimen was heated. These temperatures were determined by means of the platinum resistance thermometer visible in Fig. 3. The mercurial thermometer also shown was used merely as a rough indicator. Column B gives in microns the expansion of the specimen observed on heating it from 23.45 deg. to each temperature recorded in Column A. In obtaining these values the corrections given in Column D were added to the apparent expansions indicated by the measuring screw. For calculating the corrections the linear expansivities of the brass bar *BK* and of the Pyrex glass tube *AJ* were assumed to be 0.000018 and 0.0000032 per degree Centigrade, respectively. The magnitudes of these corrections could have been greatly reduced by proper choice of materials together with proper thermal insulation.

The precision attained in measuring the expansions is indicated by Column C, which gives opposite each temperature the average deviation in microns of the individual indications of the measuring screw from the average value observed at that temperature. The deviations here recorded, which correspond to elongation of the specimen under measurement, were obtained by dividing the corresponding deviations of the actual screw readings by 4, since the stretched wires multiplied the specimen elongations by 4. Column E shows the number of micrometer screw observations that were averaged at each temperature to obtain the values under B and C. Examination of the table shows that, for the 107 contact observations represented, the average deviation was only about 0.46 micron. This gives some idea of the high precision attainable with a stretched wire dilatometer even when the construction is as crude as that pictured in Fig. 3, which is a photograph of the apparatus actually used for obtaining these results.

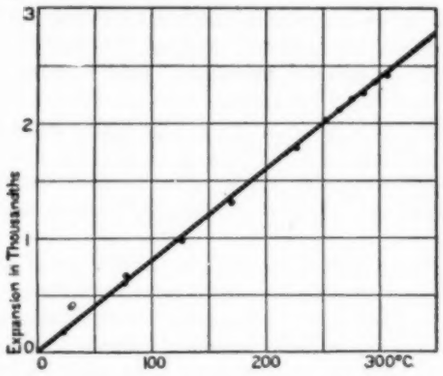


FIG. 6. THERMAL EXPANSION OF OPTICAL GLASS

THERMAL EXPANSION OF OPTICAL GLASS

A	B	C	D	E
23.45	0.0	±0.5	—2.8	7
77.51	25.5	0.6	—2.5	3
78.21	29.2	0.4	—1.0	8
127.24	47.2	0.4	+0.2	9
170.55	67.2	0.2	+2.0	6
227.83	95.8	0.3	+3.0	10
254.13	110.0	0.6	+3.2	9
265.75	115.5	0.5	+3.0	7
276.62	120.8	0.5	+3.0	9
286.39	124.2	0.4	+4.0	9
297.07	130.0	0.6	+4.5	6
307.81	133.5	0.4	+5.8	7
30.85	13.8	0.6	—2.0	7
29.96	13.0	0.5	—1.2	10

A. Temperature Centigrade.
B. Expansion in microns of 6 cm. specimen.
C. Average deviation in microns from average.
D. Correction in microns for temperature changes in apparatus.
E. Number of micrometer screw settings averaged.

A plot representing the observations recorded in the table is shown in Fig. 6. The straight line corre-

*At the request of Dr. Arthur L. Day, Optical Glass Committee, War Industries Board, the writer undertook to determine the expansivity of this glass, which had been produced under the direction of the former for naval searchlight mirrors. The dilatometer pictured in Fig. 3 was hastily designed and constructed especially for this work.

sponds to an expansivity of 0.00000794 per degree Centigrade. The last two observations, which were made the day following the observation near 308 deg., are represented by the open circles. Such failure of a glass to return to its original length upon cooling after strong heating is frequently observed.

Although Fig. 6 indicates an accuracy sufficient for most scientific or industrial purposes, it should be borne in mind that the specimen tested was only 60 mm. long and that the corrections given in Column D of the table are both considerably larger and considerably more uncertain than need be. If the errors involved in the corrections be rendered negligible by the means indicated above, the relative accuracy of the expansion measurements will be increased in the same ratio as the length of the specimen under test is increased, since the deviations in Column C represent absolute, not relative, precision in length measurement.

Variations of the Stretched Wire Dilatometer

The apparatus actually constructed as outlined above illustrates merely one particular arrangement for applying the general principles of the stretched wire method. It was hastily designed and built to meet an emergency. Various details could obviously be modified. For example, two independent graduated screws for moving the stretched wires *G* and *H* would be a convenience; any sensitive detector of contact is usable; tungsten wires are not necessary, etc. Moreover, micrometer screws can be arranged to replace microscopes for use with either an air bath (as in an electric furnace) or a liquid bath; so that the range of application even in the simplified form of dilatometer is not limited to the interval between room temperature and 300 deg. C.

Nor is the application of the stretched wire method limited to the case of thermal expansion. The writer has already used wires for measuring magnetostriction in nickel steels at temperatures ranging from —75 deg. to +300 deg. C.[7] Wires could easily be adapted to the construction of an extensometer for measuring deformations of materials during any kind of testing, especially when it was desired to control the temperature of the test piece. In fact, there appears to be no other method that is quite so reliable for accurately following linear displacements that occur in regions which are difficult of access.

Physical Research Laboratory,
The L. D. Caulk Company,
Milford, Del.

The Magnesite Industry in Austria

THOUGH the term "magnesite" is generally applied to the iron-bearing carbonate of magnesium, such is is found in Austria and Hungary, by some Austrian magnesite is referred to as bruennerite. The mineral bruennerite has become of commercial importance only in Austria. The important deposits are found in Styria, lower Austria and northern Hun- ($FeCO_3$), occurs at Eisenerz, Styria, while the world's largest deposit of spathic iron ore, or iron carbonate ($FeCO^3$), occurs at Eisenerz, Styria, while the world's largest deposit of spathic bruennerite is found at Veitsch, in the same province.

The Styrian and lower Austrian deposits are located much nearer the Adriatic Sea than are the deposits of northern Hungary; and it is from the former that most of the exported magnesite has come. They are located southwest of Vienna, and extend west from Semmering through the Murz Valley to Tyrol. The chief deposits reckoning from east to west are those of Semmering, Veitsch, Breitenau, Trieben, Radenthein and Dienten.

The largest and most important deposit is that at Veitsch, located near Mitterdorf, on the South Austrian Railroad in the Murz Valley, Styria. Here the magnesite, which occurs in the form of a lens, is quarried on the slope of a hill in a series of terraces about 50 ft. apart. The entire work extends through a vertical distance of 500 ft. The huge magnesite lens is nearly ¾ of a mile long and over 1000 ft. in width, and probably extends to a considerable depth.

The formation containing the magnesite extends where magnesite is quarried beyond Jolsva and Nyustya, in the Gomer district. In spite of the remote location of these deposits as compared with those in Styria, magnesite was shipped from them before the war a distance of 360 mi. to the port of Fiume for overseas shipments to other parts of Europe and to America.

The average analysis showing the composition of the mineral found in Austria-Hungary is as follows:

	Per Cent		Per Cent
Magnesia	33 to 44	Silica	1 to 5
Lime	1 to 3	Carbon dioxide	50
Ferrous oxide and alumina	2 to 7	Water	.....

Character of the Sintered Product

The magnesite occurs as lenticular masses in a belt of carboniferous rocks consisting mainly of metamorphosed shales, sandstones, conglomerates and limestone. It is grayish in color when fresh, and contains sufficient ferrous carbonate to blacken it when calcined. It turns brown owing to the oxidation of the ferrous carbonate when exposed to the air. The quantity of carbonate of iron is variable and different analyses show that it ranges up to 13 or 14 per cent.

For the most part, only the sintered article has been imported into the United States. This material has achieved an enviable reputation for its uniformity both as to chemical and physical characteristics. The homogeneity of the sintered Austrian magnesite is doubtless due in part to the averaging effect of the different operations, such as crushing, dressing, sintering and mixing, an effect which is not obtainable in mere hand samples.

There is comparatively little variability in the sintered magnesite as marketed, and five analyses of this sintered magnesite as quoted by Cornu[1] are as follows:

	Per Cent
Magnesia (MgO)	85.53 to 90.07
Lime (CaO)	0.96 to 3.52
Ferrous oxide (Fe_2O_3)	7.43 to 9.96
Alumina (Al_2O_3)	0.00 to 2.22
Manganese oxide (Mn_3O_4)	0.51 to 0.76
Silica (SiO)	0.26 to 1.34

Quarrying and Preparation

The methods of quarrying and preparing magnesite

[1] F. Cornu, *Z. Prakt. Geol.*, 1908.

[7] A. W. Gray, D. H. Sweet and L. W. Schad: "Some Effects of Magnetization on the Length of a 35.25 Per Cent Nickel Steel," *Phys. Rev.*, vol. 7, p. 684, 1916.

in Austria and Hungary are similar at most of the different plants. On the outskirts of the village of Veitsch, about 56 mi. southwest of Vienna, is found one of the largest deposits, and one which has been worked the longest. Since the methods of mining and preparation here are fairly typical, they will be outlined.

As stated above, the magnesite quarry at Veitsch is worked in a series of steps or levels about 50 ft. apart vertically. The material is blasted out of the solid by the ordinary methods of rock quarrying. It is next broken in pieces which can be handled readily by one man, and the dolomite and quartz are carefully picked out. Even in the best of the deposit, there is a large quantity of this gangue material, and estimates of the waste rock vary from 50 to 66⅔ per cent of all the material quarried. Terrace quarrying and working conditions in general like these at Veitsch are practiced at Breitenau and at Eichberg.

The coarse quarried material is cobbed to free it as far as possible from impurities like chist, dolomite and quartz, and the lumps are sorted. The cleaner portions of the magnesite are reduced to pieces about the size of a man's head. Less pure portions have to be broken into pieces about the size of a man's fist. These dressing operations involve a considerable loss of magnesite in the form of small fragments, too small to be burned in shaft kilns. The raw material thus obtained in the quarries at Veitsch is transported by gravity planes to the sintering kilns at the foot of the hill.

Sintering Temperature

According to Morganroth,[2] continuous kilns of the bottle variety are used and producer gas is employed as fuel. These kilns burn on an average of 15 to 24 tons of calcines per 24-hr. day. Within the last few years, a few plants have installed rotary kilns of the cement type to burn the magnesite, powdered coal being used as fuel. The capacity of these kilns is 50 to 60 tons per 24-hr. The magnesite can be burned as thoroughly in these kilns as in the bottle kilns, but they have one disadvantage in that a larger per cent of fines is produced. The magnesite as burned in the bottle kiln is drawn every 6 hours.

The sintering temperature varies from 1500 deg. C. (2350 deg. F.) for bruennerite containing considerable iron oxide to 1700 deg. C. (3100 deg. F.) for material poor in iron oxide. However easily the material sinters, it appears desirable to carry the temperature up to at least 1500 deg. C. (2700 deg. F.), but this temperature seems to be exceeded, as a rule, in the shaft kilns in Styria.

Treatment of the Crushed Sinter

The magnesite, after being drawn from the kilns, is quenched with water and crushed to walnut size or less. It is then classified mechanically by screening or sizing into three different sizes. Much of the caustic lime or calcined dolomite is removed in the first screening owing to its finely divided condition. From the screens it goes to the picking tables, where the underburned magnesite, together with the dolomite and quartz, present in particles too small to have been removed at the quarries, is picked out. These are light colored, and consequently readily distinguishable. The magnesite in the larger sizes is again crushed and the smaller pieces repicked. The magnesite is finally crushed to the size of kernels of corn, picked over again, and sacked for the trade in packages of 150 to 200 lb. each.

In recent years, magnetic separators have been introduced which have resulted in an economy in the picking or sorting operation. If not magnetically treated, the finely divided material marketed would necessarily contain particles of schist, quartz or other non-magnetic minerals. It must be said, however, that the magnetic treatment involves some waste, since only magnesite containing iron is removable by this treatment. It adds to the expense and is presumably employed only when it is necessary to obtain a concentrated, uniform and most highly refractory product.

In addition to the milling and sintering plant at Veitsch, where operations are as outlined above, there are other localities in Styria where work is done in a similar manner, for example at Breitenau, Trieben and in lower Austria at Eichberg, near Gloggnitz.

Fuel Required

The amount of fuel required to sinter Austrian magnesite varies and is dependent in part on the quantity of the ferrous carbonate present. With good flaing brown coal, having a heating value of 6000 calories, the quantity required varies from 600 to 800 lb. per ton of sintered magnesite. The fuel requirement has been estimated by others at 1000 lb. per ton of sintered magnesite produced. The latter coal, however, has a calorific value of only 4000.

The abundance and accessibility of the brown coal used in sintering Austrian magnesite has been a very important factor in the cheapness of past production.

Other Commercial Conditions

At Veitsch the marketable sinter is trammed on an aërial tramway about 4 mi. long to Wartberg Station. The works at Trioben are near the station, which is located about 3 mi. from the deposit at Sunk, where the material is quarried. At Pradenthein, work was begun by American capital in 1908, and from that time till the war cut off the supply a great deal was shipped to Philadelphia, New Orleans and New York. The shipments from Europe were usually made through the port of Trieste, and before the war ocean freight per ton was $2.50.

The facts that the Austrian deposits are large and are easily quarried; that they are within easy reach of transportation facilities, and the additional fact that labor, at least before the war, was cheap have all tended to give Austrian magnesite commercial supremacy in the world's markets. These conditions, moreover, help to explain the success which Austrian magnesite has achieved in the past and indicate the possibility of the competition which it may be able to exert in the future. Only the massive deposits of the Veitsch type can be quarried and worked at a profit, however, and some of the larger deposits, not well located, have been unable to compete in the past.

[2] *Bulletin*, American Institute of Mining Engineers, No. 93, 1914, pp. 2345-2452.

Melting of Some Non-Ferrous Metals and Their Alloys in Electric Furnace

Requirements for Economic Melting of Non-Ferrous Metals and Their Alloys—Adaptability of a Contact Arc Resistance Type Furnace—Melting Cost in Electric vs. Fuel-Fired Furnaces—Sources of Losses—Tabulated Data

BY E. F. COLLINS

SATISFACTORY and economical melting of non-ferrous metals and alloys requires a furnace of the following specifications:

Dependability and continuity of operation.

Freedom from oxidization of metals or alloys while in the furnace; in fact, deoxidation of metals or alloys in some degree is usually advantageous.

Freedom from volatilization of metals should exist subsequent to their liquefication and while in the molten state, to prevent loss of metal in the form of escaping vapor, which usually oxidizes upon its escape from furnace to air, when the furnace atmosphere is neutral or reducing, i.e., free from oxygen.

Freedom From Slags

The slags, which are due to overheated linings, dirt from scrap, oxides from metals, etc., should not mix with the melted metal. This allows of dry skimming (during melting) of dirt, sand and other impurities, without entrained metal in the form of shot in the fused slag, that must subsequently be crushed and the metal reclaimed by more or less elaborate process. The furnace should not require the maintenance of an elaborate and expensive reclaiming plant. In other words, impurities should float on top of the bath in the furnace and allow of skimming this from the surface of the bath. It should allow of the use of sal ammoniac or other flux to aid in cleaning the metal while molten in the furnace, but should not regularly require the use of such flux to give perfect metal; neither should the bath require charcoal covering while melting or subsequently while held in furnace.

Uniformity of alloy and absence of segregation should exist when the furnace charge has reached the pouring stage, i.e., test bars should show uniform physical characteristics throughout their length, a perfect fracture, satisfactory crystallization and lack of segregation under microscopic examination.

Melting Chambers and Their Size

The furnace linings and atmosphere must be free from the slightest degree of sulphur, and the furnace atmosphere must be controllable as regards oxygen when melting copper and many alloys rich in copper, in order to produce satisfactory foundry castings of sound metal, since copper greedily absorbes sulphur and oxygen when hot, which gives rise to trouble on cooling. In fact, furnace melting chambers should be free from contaminating influences, coupled with a controllable atmosphere with respect to oxygen, in which case electrolytic cathodes, free from salts of the electrolytic bath, may be melted down and poured "at pitch" without "rabbling and poling." This will eliminate the use of the present day reverbatory copper refining furnace and allow of making brass directly from cathode copper as well as cathode zinc, thus saving one refining operation on copper and one melting or "pigging" operation on zinc.

The melting chamber should be arranged so that its atmosphere may be reducing, neutral or oxidizing for certain metals and alloys, i.e., its oxygen should be controlled. A certain flow of gas through the furnace may be required at times and at others a "dead" or "still" atmosphere is absolutely necessary. No advantage, however, is secured in attempting to seal hermetically the furnace unless some process of distillation is attempted. Hence, if the furnace is provided with doors, it is only necessary that they close in such a manner, and are of such construction, as to prevent an undue loss of heat and circulation of gases in the furnace when they are closed. A single small opening in the furnace, such as is required for stirring the bath or pouring, may produce a sort of breathing of the furnace when the vent is open, but the loss of heat or metal is not appreciable if the furnace is being properly manipulated.

Large-capacity furnaces which do not involve the use and handling of crucibles are desirable where local conditions will permit. Large furnaces promote economy, due to higher thermal efficiency, saving floor space in proportion to metal melted, saving in labor, saving in cost of lining per ton of metal melted, especially when compared to crucible cost, their storage, drying and tempering, spill from broken crucibles, etc.

Where metal is melted in large furnaces, preheated hand ladles or crucibles are used to transfer the molten metal to molds where small foundry castings are being made, and it is important that these ladles or crucibles be well and properly preheated before using, especially when pouring small parts such as ½-in. brass valves, etc., in order to get satisfactory work. The burden of the preheated crucible is eliminated several times over by the many advantages coupled with the use of the non-crucible tilting furnace above ordinary crucible capacities.

Furnace Linings

Furnace linings should in the main be built of commercial refractories of moderate cost, which are at all times available, such as standard fire brick and shapes, with limited use of special refractories where the results justify their usage, rather than of special refractories, which can be procured only at high price and with more or less difficulty and uncertainty. If the foundry man or metal melter will make repairs upon his linings at least once every two weeks, and when in severe service once each week, his lining cost will be much less than when special high priced refractories are used and repairs and inspection of linings are less frequent. The refractoriness of linings should be such that they will not fuse or slag perceptibly at melting temperatures. Their inner surface should be glazed over at tempera-

tures above the metal melting zone. This guards against slag formation during the melting process, assuming that no chemical reaction occurs between metal and hearth to reduce the fusion point of the refractories. As an illustration, the presence of lead in brass melting fluxes the refractories at temperatures at which they are immune in contact with the same bath free from lead.

Heat Distribution

Shallow baths promote a more uniform and rapid melting and freedom from segregation than the deep bath. The source of heat should be a uniform, mild, "soaking" heat, and its temperature gradient above the bath should be moderate; that is, due to a large absorbing surface, the bath takes in a large quantity of heat at a low heat potential. The transfer of heat to the metal is accomplished most successfully by radiation to the top of the bath and conduction to the bottom. In case the source of heat is only slightly higher than the charge when the fusing point of metal is reached, the metal may be held for an indefinite period within that zone of temperature above the fusing point in which vapor tensions are not sufficiently high to cause appreciable loss of metal from volatilization. In other words, if the source of heat is such that its temperature lies in the temperature zone safely below the destructive distillation point of the metal, then the bath can in no manner exceed it. A safe way in securing this heat control is to limit the temperature of the heat source by means of a pyrometer. Pyrometers are available at present which live for a satisfactory period in certain brass furnaces, which makes their use entirely practical. It follows from the above that furnace design should be such as to allow of the source of heat being held at any temperature desired.

The heat distribution should be fixed and if possible automatically controlled; i.e., heat received by radiation as related to that received by conduction should be such as to secure a uniform heat of the bath. If any variation in the ratio of heat radiated to top of the bath and that conducted to bottom is permissible, this variation should allow of a reduction of radiant heat at the top of the bath at once when the fusing temperature is reached, because when the bath is liquid its bottom convected heat will give uniformity of temperature to the bath.

The foregoing sets forth more or less in detail the requirements for economy in melting brass alloys. It is now desired to consider the characteristics of the electric furnace and see how completely it overcomes the obstacles met with in the fuel-fired furnaces for melting non-ferrous metals and their alloys.

Classification of Electric Furnaces

Class I comprises furnaces in which heat is developed by the passage of current through a solid, laminated or granular conducting medium or resistor.

(*A*). The conducting medium may consist of material that is to be treated.

(*B*). The heat developed in the "resistor" is transferred to the charge by conduction or radiation or both; a wall may or may not intervene between the "resistor" and the charge.

(*C*). A readily controllable amount of heat is generated between a fixed and movable carbon electrode, their distance apart being maintained such that the granular carbon lying between the faces gives rise to many chains of series and multiple contact or resistance arcs, enveloping adjacent electrode faces.

Class II comprises furnaces in which heat is developed by the flow of current through a liquid or solid conductor.

(*A*). Electrolytic.

(*B*). Non-electrolytic.

Class III comprises furnaces in which heat is developed by flow of current through gas or air arc furnaces.

In the making of brass, furnaces lying in each of the three classes have been tried out. Furnaces lying in Classes I and II lend themselves readily to the generation and control of a mild, "soaking" heat such as is required for melting volatile alloys. As illustration, the common resistance furnace lies in Class I, and the induction furnace in Class II. Furnaces in Class III generate a too intense and burning heat to be used with even questionable success in melting volatile alloys without the use of much unnecessary manipulation and watchfulness requiring much skill. Control of the electric arcs in atmospheres high or low in volatile gases, freedom from surging, low power factor and high metal loss are some of the serious problems confronting the man who would melt volatile alloys in the Class III arc furnace. Their employment had best be left for steel.

Adaptability of Type C Resistance Furnace

A furnace falling in Class I and Type C of the above classification has proved, upon experience gained from many tests as well as from its commercial operation in the foundry, that it is the best adapted for melting non-ferrous metals and their alloys.

Its design, construction and the reasons why it is suited to melting the non-ferrous metals and their alloys are given below somewhat in detail.

Description and Design of Furnace

An example of this type of furnace is shown in Figs. 1 and 2. It will be noticed that it consists essentially of a refractory lined case within which are located in the same chamber the heating units lying on either side of the melting hearth (3). The source of heat is 13 and lies in a duct separated from the bath by carborundum walls 5 and 6. This duct is fitted with cross electrodes 9 and with wearing blocks 12 under each of two vertical electrodes projecting through the arched roof. These cross electrodes in the bottom of the duct, as well as the wearing blocks between them and the vertical electrodes, are of carbon. The whole duct is filled with granular soke to the height of the bridge wall 5 and 6 on either side of the hearth. Neutral electrodes 16 and 17 make contact with the cross electrodes 8 and 9. These neutral electrodes are for the sake of automatic control, as will be seen later. The vertical electrode carries a water-cooled ring where it emerges from the top arch. The cable clamp for electrode 15 is also water-cooled. The two vertical electrodes 11 are terminals of one phase, while those marked 10 are terminals of another. In other words, the furnace is inherently 2-phase. By multipling the 2-phase, however, it may be operated single phase, or by using Scott transformer connections it may operate from 3-phase source. The phase voltage most satisfactory has been found to be 60 to 70 v. The detailed arrangement of the electrodes, etc., in resistor duct is evident.

The operation of the furnace in generating heat is as follows:

The current supplied to the furnace flows through the vertical electrodes 10 and 11 through a short space filled with granular carbon to the wearing block 12, into the cross electrodes 9, into second wearing block 12′ and out to line through second granular coke strata and second vertical electrode. The value of the current is regulated automatically by varying the distance between the vertical electrodes and the wearing block. In other words, by means of a current-controlled relay the distance between 11′ and 12′ is governed; also by means of a voltage-controlled relay connected to neutral bottom

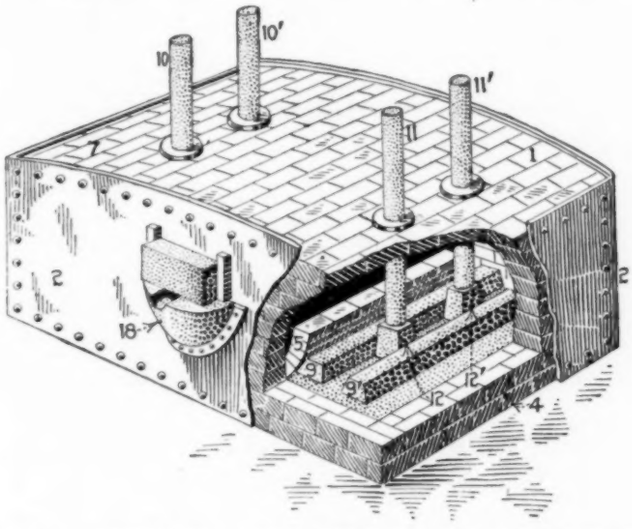


FIG. 1. SCHEMATIC VIEW CONTACT ARC RESISTANCE TYPE FURNACE

electrodes and vertical electrode 11. The distance between electrode 11 and wearing block 12 is held to correspond to one-half the phase voltage, i.e., 30 to 40 volts. A rheostat on the control panel allows of setting control for any current value required, and when once set for a given value, such value is held until the rheostat position is changed by the furnace operator. Hence the power input is automatically held constant and is

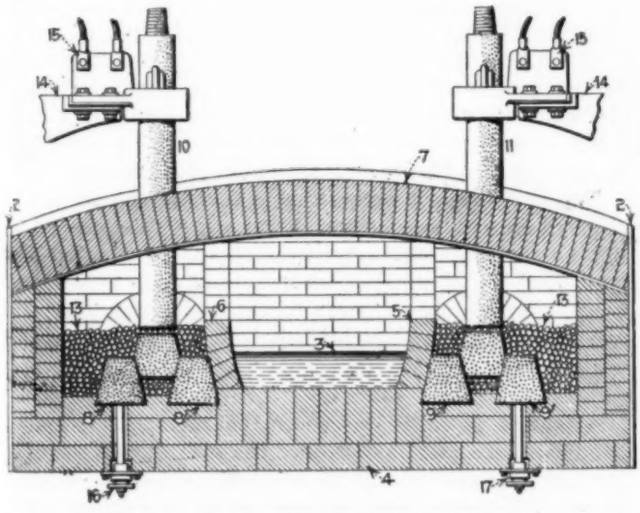


FIG. 2. SECTION OF CONTACT ARC RESISTANCE TYPE FURNACE

subdivided equally between the vertical electrodes. Starting with a cold furnace the heat is generated first in the granular carbon separator lying under the bottom face of the vertical electrode. This immediately becomes incandescent by virtue of the current carried by the carbon granules, and heat is also generated by a multitude of contact arcs enveloping the lower end of the vertical electrode. Heat is at once taken from this source by the granular coke in the trench and its whole surface becomes heated to the desired point. The surface of the granular carbon radiates heat to the arched roof, and the body of granular carbon and wearing block with the cross electrodes conduct heat to the furnace walls and to the sides and bottom of the hearth with which they are in contact. Furthermore, as the furnace becomes heated a certain amount of current flows from the vertical electrode 11 to vertical electrode 11′ directly through the granular coke in a way similar to the simple carbon resistance furnace. This heat may be as much as 30 per cent of that developed locally at each vertical electrode as above described through contact arcs and resistance. This heat is largely radiated to the roof, since it is generated largely in the upper surface of the coke body. In addition to serving as enclosing wall of the furnace, the roof is so shaped that it acts also as a highly efficient reflector, throwing the heat received from the incandescent coke ducts on either side of the hearth uniformly on the hearth or bath. This heat is very uniform and what is called a mild "soaking heat," and

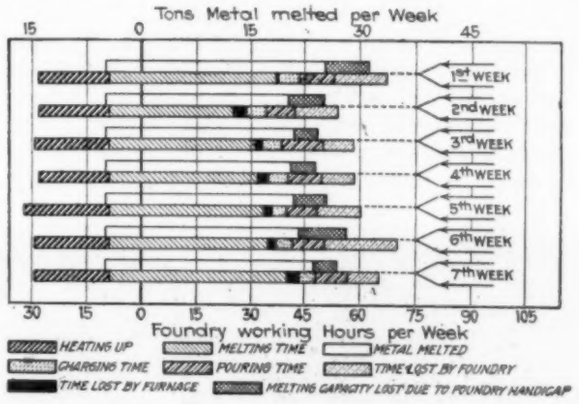


FIG. 3. CHART SHOWING CONTINUITY OF SERVICE OF ELECTRIC FURNACE MELTING BRASS IN

hence lends itself well to the melting of brass or volatile metals; especially is this a fact since a part of the heat is supplied to the bath from the bottom and sides.

Some Characteristics of the Furnace

To enumerate briefly some characteristics of the above-described furnace which makes it essentially suited to melting non-ferrous metals and their alloys, we have the following:

1. The temperature of the heat generating source is controllable at will.
2. The heat generated is of the mild "soaking" type, uniformly distributed, and any workable temperature gradient may be maintained between the charge and the heat source.
3. The heat is received by the charge from above, on the sides and through the bottom.
4. The bath is comparatively shallow and a large surface is exposed to receive the heat. (The bath depth is approximately 6 in. in a 1500-lb. furnace.)
5. The furnace has normally a reducing atmosphere, which may readily be made neutral or oxidizing.
6. Automatic control of power, requiring little attendance.
7. The furnace atmosphere is free from contaminating gases.
8. A "dead atmosphere" practically restrained from escape exists normally in the furnace.

9. The temperature is controllable, so that slags do not form in melting brass. Hence simplicity of metal recovery from the dirt skimmed from the top of the bath in the furnace.

10. The furnace may be "forced," i.e., the heat may be fed to the metal as fast as it is absorbed, and a high rate of melting results with all its advantages and with none of the disadvantages met with in fuel-fired furnaces.

11. Dependability of furnace and continuity of operation under commercial conditions as illustrated in Fig. 3. The delays due to the furnace are of short duration when compared to the time the furnace was delayed due to foundry conditions; in other words, little melting capacity was lost and chargeable to the furnace as compared to that lost due to delays for which the foundry alone was to blame.

Fig. 4 shows a working installation of a furnace of the type described, which has a melting capacity of 1500 lb. of brass per hour. The most recent design of this type of 1500-lb. furnace is shown in Fig. 5.

Induction Furnace vs. Resistance Furnace

The induction furnace is said to be exceptionally efficient thermally while melting. Its overall working efficiency for the week is not appreciably different from that of the resistance furnace; but it is desired to call attention to the fact that kw.-hr. per ton consumed in melting may by no means indicate the highest overall working efficiency.

Suppose, for illustration, we concede that the induction type of furnace has the highest thermal efficiency in melting. A certain furnace of this type has a crucible capacity of 400 lb. and a load loss or radiation of 8 kw.-hr. per hr. and melts a charge of red brass each hour. Suppose the charge is poured at 1300 deg. C.; it is necessary to use hand ladles preheated in pouring the charge. The furnace must be kept hot 24 hr. per day

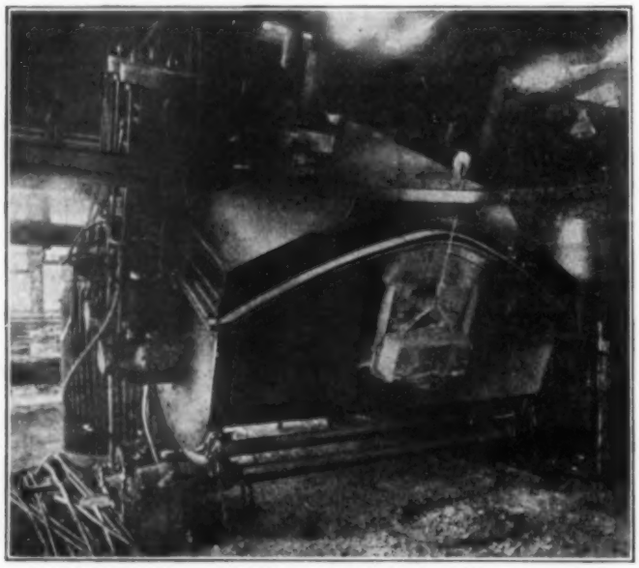


FIG. 4. 1500-LB. 300-KW. BRASS-MELTING FURNACE

when the crucible has once been heated up. Let us now compare the effective working kw.-hr. consumption per ton with that of a 2250-lb.-per-hour tilting type resistance furnace of the design described and melting 18,000 lb. of red brass per 8-hr. day. It will be noted that this furnace may be charged by machine, whereas the crucible furnace must be carefully charged by hand. The pouring of the charge will be by hand with preheated ladle, and should cost the same as pouring a like quantity of metal from crucibles.

It seems, since five to six 400-lb. crucible furnaces must be employed to give the same metal output as one 2250-lb. tilting furnace, that labor of attendance charging and melting per ton should cost at least 2¼ times as much in a crucible furnace as in a tilting hearth type Hence, it follows from the above:

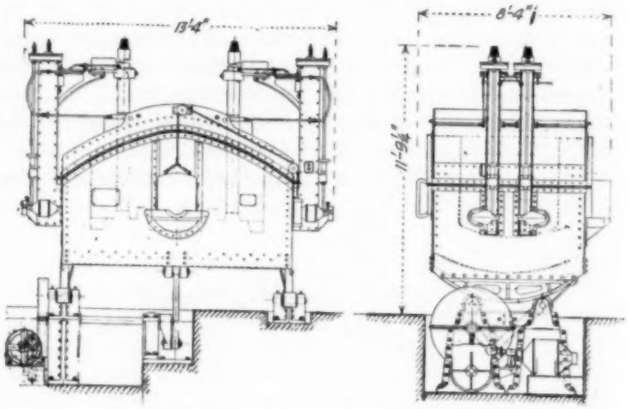


FIG. 5. CLASS I, TYPE C, BRASS-MELTING FURNACE, CONTACT ARC RESISTANCE TYPE

Metal melted per week in 400-lb. crucible induction furnace 8-hr. working day	48 × 400 = 19,200 lb.
Kw.-hr. to melt 19,200 lb. at 200 kw.-hr. per ton	200 × 9.6 = 1,920 kw.-hr
Kw.-hr. to keep furnace hot while not melting (24 × 7 = 168), 168 — 48 = 120 hr. per week	120 × 8 = 960
Total kw.-hr. per week	2,880
Kw.-hr. per ton	2,880 ÷ 9.6 = 300
Power cost per ton at $0.01 kw.-hr	$3.00
Excess labor cost of 400-lb. crucible furnace over 2250-lb. tilting hearth per ton	1.25
Total	$4.25

This $4.25 is the power cost that may be allotted per ton to the 2250-lb. furnace and maintain an equal all-week efficiency for the same total amount of metal melted by either furnace. In other words, if the large tilting furnace melts with the not unexpected consumption of 425 kw.-hr. per ton, it has equaled the performance of the induction crucible furnace, which, offhand, seems much more efficient because we say it melts for 200 kw.-hr. per ton. Large-capacity induction furnaces might change the above somewhat, but the writer does not know of any successful design on the market at present for melting brass in capacity exceeding 600 lb. In fact, these are limited in their use to certain mixtures only. Leaded brass above 3 per cent cannot be successfully handled, due to the fluxing action on crucibles, etc.

The above clearly shows that a furnace should not be selected merely because it melts at a low kw.-hr. per ton, but all its other characteristics should be studied and its overall cost of turning out metal should be considered, when conforming to local conditions, since different working cycles may give widely different overall results.

Cost of Electric Melting vs. Fuel-Fired Furnaces

Attention is called to certain characteristics, losses, handicaps, etc., which influence the overall cost of melting and must be considered in making up true melting costs. These will now be considered and their effect shown upon costs as tabulated in Table I.

This table gives average data by which one may judge correctly as to the general problem of electric vs. fuel-fired furnaces. Results for individual foundries may be readily found by substituting in the itemized costs those which correspond to local conditions, Thus: 1.5c. per

TABLE I—AVERAGE COST OF MELTING BRASS WITH FUEL-FIRED OR ELECTRIC FURNACE

Furnace type	Pit	Pit	Tilting	Pit	Reverb.	Pit	Tilting	Crucible	Crucible	Tilting
Furnace draught	Natural	Forced	Forced	Natural	Natural	Forced	Forced	Burner	Burner	Electric
Furnace fuel	Coke	Coke	Coke	Coal	Coal	Oil	Oil	Natural gas	City gas	Electric
Fuel cost price	$9.75	$9.75	$9.75	$8.00	$8.00	$0.098 gal.	$0.098 gal	$0.30M.	$0.60M.	$0.015 per kw.-hr.
Cost per Ton, Making Red Brass, Pouring at 1300 Deg. C. Zn 10 Per Cent or Less										
Fuel quantity	1400	700	600	1200	900	50 gal.	60 gal.	4800	7000	400 kw.-hr.-10 hr. 250 kw.-hr.-24 hr.
Metal loss	70	30	30	70	124	30	44	40	40	15
Fuel cost	$6.82	$3.41	$2.92	$4.80	$3.60	$4.90	$5.88	$1.44	$4.20	$6.00—$3.75
Zinc value at 10c./lb.	7.00	3.00	3.00	7.00	12.40	3.00	4.40	4.00	4.00	1.50 1.50
Cost reclaiming	.50	.50	.50	.50	.50	.50	.50	.50	.50	.15 .15
Renewals and repairs	.40	.40	.35	.40	.50	.50	.50	.35	.30	1.00 1.00
Cost preheating crucible	.40	.40	.40	.40	.40	.40	.10	.40	.40	.10 1.10
Furnace labor	2.25	2.25	2.25	2.25	1.50	2.25	1.50	2.25	2.25	1.00 1.00
Miscellaneous and labor and fuel	.50	.50	.50	.50	.50	.40	.40	.40	.40	.20 .20
Cost charcoal	.12	.12	.12	.12	.12	.12	.12	.12	.12	.05 .05
Air for blast	.....	.15	.15	.....	.....	.15	.15	.15	.15	....
Crucible cost	5.00	5.50	5.50	5.00	.....	8.00	.....	8.00	8.00	....
Interest—Crucible stock	.10	.10	.10	.10	.....	.10	.....	.10	.10	....
Lining pouring crucible	.....	.....	.30	.....	.30	.....	.30	.30	.30	.30 .30
Electrodes and coke	.....	.....	.....	.....	.....	.....	.....	.....	.....	.60 .60
Cost per ton—Total	$23.09	$16.33	$16.09	$21.07	$19.82	$20.32	$13.85	$18.01	$20.72	$10.90 $8.65
Cost Per Ton; Making Yellow Brass. Zn 10 to 40 Per Cent										
Fuel quantity	1000	600	400	700	400	40 gal.	45 gal.	.....	.....	350 kw.-hr. 10-hr. day 220 kw.-hr. 24-hr. day,
Metal loss	100	40	56	100	200	60	70	.....	.....	30
Fuel cost	$4.88	$2.92	$1.95	$2.80	$1.60	$3.92	$4.41	.....	.....	$5.25 $3.30
Zinc value at 10c./lb.	10.00	4.00	5.60	10.00	20.00	6.00	7.00	.....	.....	3.00 3.00
Cost reclaiming	.50	.50	.50	.50	.50	.50	.50	.....	.....	.15 .15
Renewal and repairs	.40	.40	.35	.40	.50	.50	.75	.....	.....	1.00 1.00
Cost preheating crucible	.40	.40	.40	.40	.40	.40	.10	.....	.....	.10 .10
Furnace labor	2.25	2.25	2.25	2.25	1.50	2.25	1.50	.....	.....	1.00 1.00
Miscellaneous and labor and fuel	.50	.50	.50	.50	.50	.40	.40	.....	.....	.20 .20
Cost charcoal	.12	.12	.12	.12	.12	.12	.12	.....	.....	.05 .05
Air for blast	.....	.15	.15	.....	.....	.15	.15	.....	.....	....
Crucible cost	4.50	5.00	5.00	4.50	.....	4.50	.....	.....	.....	....
Interest—Crucible stock	.10	.10	.10	.10	.....	.10	.....	.....	.....	....
Lining pouring crucible	.....	.....	.30	.....	.30	.....	.30	.....	.....	.30 .30
Electrodes and coke	.....	.....	.....	.....	.....	.....	.....	.....	.....	.60 .60
Cost per ton—Total	$23.65	$16.34	$17.22	$21.57	$25.42	$18.84	$15.23	.....	.....	$11.65 $9.70

kw.-hr. has been used as electricity or power cost; if this is 1c. in the plant under consideration, this figure should be substituted. Likewise other values may be converted to actual ones for an actual local condition.

TABLE II—SOURCES OF METAL LOSS IN MELTING

	Electric	Fuel Fired
Temp. control	Excellent	Indifferent
Size of charge	Controllable	Controllable
Gas flow from furnace	Negligible	Large volumes if combustion gases must pass out
Furnace atmosphere Chemical condition	Free from oxygen and injurious gases	Contaminated by impurities of fuel. Protection against oxygen only through excess fuel supply
Speed of melting	Much greater than fuel-fired	Much less than electric

It will be noted from Table II that conditions are under absolute control in the case of the electric, whereas in fuel-fired furnaces the control of temperature is indifferent, and large volumes of gases of combustion must pass through the furnace. Likewise, since heat is generated through the oxidation of fuels, the furnace chamber cannot be free from oxidizing and contaminating influences upon the metal.

First Source of Loss

Temperature Control. In a given electric furnace, the amount of metal lost in melting increases as the temperature for forming the alloy lies above the melting point of the alloy. Lack of temperature control may increase the metal losses in melting brass, as illustrated by the following tests: First, 70:30 brass is made in the electric furnace, taking 420 lb. of copper and melting down and then adding 180 lb. of zinc, at 1170 deg. C., pouring at 1150 deg. C. Second, 420 lb. of copper was melted down and 180 lb. of zinc added at 1100 deg. C. and pouring at 1100 deg. C., with results shown in Table III.

TABLE III.

Yellow Brass Metals	Temperature of Alloying	Pouring Temperature	Alloy Recovered lb.	Per Cent Zn Loss	Per Cent Metal Loss
(a) 420 lb. Cu, 180 lb. Zn	1170 deg. C. 2140 deg. F.	1150 deg. C. 1150 deg. C.	565	19	5.8
(b) 420 lb. Cu, 180 lb. Zn	1100 deg. C. 2010 deg. F.	1100 deg. C.	590	5.6	1.6
The chemical tests corresponding to the above are:					
(a) Cu 70, Zn 30	1170 deg. C.	1150 deg. C.	Cu 75.9, Zn 24.1	24	7.3
(b) Cu 70, Zn 30	1100 deg. C.	1100 deg. C.	Cu 71.3, Zn 28.7	5.5	1.6

The results in Table III show the effect of temperature on the same metal (yellow brass) and how one may readily control the melting loss in the electric furnace by observing the alloying or pouring temperatures.

Second Source of Loss

Size of Charge. Pounds metal lost on melting is independent of the charge in a given electric furnace, free from ventilation.

Metal Melted, Lb.	Charge, Lb.	Charge, Per Cent of Capacity	Temp. Melt Deg. C.	Metal Loss Per Cent
2696	674	70	1100	1.4
3727	932	100	1200	1.3

Third Source of Loss

Gas Fow From France. In the fuel-fired furnace the magnitude of loss from this source is influenced by the speed of melting, and by the pressure, volume and velocity of the gases flowing over the melting metal. Thus increasing the atmospheric pressure in the furnace and decreasing the volume and velocity of the gases tend to reduce the volatilization loss. For each fuel there is a maximum limit to gas speed or velocity through the

furnace, since each fuel in developing the required heat units to get the heat out at a given speed must develop a certain volume of gases which must pass out. Hence proper gas velocity is inseparably connected with products of combustion results from various fuels. Approximate volume of flue gases averages in coal, coke and oil furnaces from 3350 to 5800 cu.ft. per 100 lb. of metal melted. Hence it is easy to see how the flow of gas may bring about a very large volatile loss in the fuel-fired furnace. In the electric furnace the gas flow is very small, and consequently, though its atmosphere be saturated with metal vapors, so little gas leaves the furnace during the melt that the loss resulting is negligible.

TABLE IV. METAL RECOVERY TEST

(Actual Test on Red Brass)

Metal Charged	Metal Recovered	Per Cent Loss	Type Furnace
1 heat, 1500 lb.	1465 lb.	2.33	Electric tilting
1 heat, 1500 lb.	1484 lb.	1.07	Electric tilting
4 heats, 250 lb.	980 lb.	2.00	Coal-fired crucible
4 heats, 250 lb.	990 lb.	.85	Coal-fired crucible

The chemical analysis for melting loss on the same electric furnace, and the same metals, showed approximately 0.4 per cent Zn loss.

	Sn	Pb	Cu	Zn	Fe
Analysis of metal charged	4.30	6.55	80.88	8.02	0.25
Analysis of metal poured (no charcoal)	4.29	6.60	81.46	7.61	0.25

TABLE V. ACTUAL TEST (YELLOW BRASS) ELECTRIC FURNACE

	Metal Charged	Metal Poured	Per Cent Loss
	600 lb.	590 lb.	1.67
Metal recovery test	Charged Cu 70	Zn 30	
Analysis metal loss	Poured Cu 71.3	Sn 28.6	

TABLE VI. ELECTRIC FURNACE MELTING PHOSPHOR BRONZE

Metal Recovery Test (Actual):
Metal charged, 2696 lb. Metal poured at 1100 deg. C., 2656 lb. Loss, 1.4%
Metal charged, 3727 lb. Metal poured at 1200 deg. C., 3678 lb. Loss, 1.3%

Physical Test of Metal:
Open flame oil furnace and electric furnace melting same kind of brass.

	Electric Furnace	Oil Furnace
Tensile strength	27,900	24,969
Yield point	10,844	9,850
Elastic limit	7,300	7,000
Elongation in 2 in., per cent	19.4	16.9
Elongation in 8 in., per cent	17.2	14.9
Reduction of area, per cent	21.4	19.7

	Crucible Furnace	Electric Furnace
Tensile strength	30,250	30,820
Elastic limit	17,833	18,000
Elongation, per cent	16.14	19.37
Reduction of area, per cent	16.10	22.00

Fourth Source of Loss

Oxidation and Gas Absorption. Copper, zinc, tin and lead, the constituents of commercial brasses, are all very readily oxidizable at the temperatures to which they must be heated for melting and pouring. Oxidizing results in loss of metal and actually burns the metal to a dross. One can readily maintain a neutral or reducing atmosphere in the electric furnace, but it is certain that carbon monoxide must be so high and oxygen so low that one cannot, in ordinary furnaces, hope to maintain a reducing atmosphere without sacrificing many heat units through burning carbon to CO instead of CO_2.

Gas absorption is proportional to the temperature and the time the metal is held in contact with the gases. Incidental and intimately connected with oxidation of the metal is the absorption of gases. In melting the constituents of an alloy, a gas may enter into chemical union with some of its metals, forming oxides, or they may be occluded in the alloy. As an illustration: When silver is molten (1020 deg. C.), it can absorb about 20 times its own volume of oxygen. On cooling it gives up the oxygen absorbed, as evidenced by the well known spitting of silver on freezing. Absorption of gases is greater as the temperature increases. Since, when the metals freeze, absorbed or dissolved gases are given up, if these are unable to pass through the metal before it freezes it will produce sponginess and blow-holes in the alloy. The same effect may be produced by air trapped in pouring, by gases evolved by molds or cores when hot metal enters them; but dissolved gas is unquestionably a principal source of porosity and blow-holes. All fuels used in the foundry at the present time contain sulphur in some degree. This sulphur is a very common cause of trouble. Melted brass absorbs sulphur greedily and gives it up on cooling in the sand molds and forms porosity and blow-holes. One successful brass foundry asserts that many of the failures usually attributed to oxygen are really due to sulphur. In the most careful crucible melting in coke-fired furnaces, the metal will absorb 0.002 to 0.005 per cent sulphur. Sulphur accumulates in a metal each time it is melted, which accounts for dark skin on re-run castings as compared with first melt metal. In fact, even though melted under a charcoal cover and CO blanket, copper needs a deoxidizer to free it completely from oxygen. These troubles should not occur in connection with electric melting, since the furnace chamber may be kept uncontaminated and free from oxygen and injurious gases.

TABLE VII. NON-FERROUS METALS MELTED IN ELECTRIC FURNACE

Metal	Condition of Metal Charged	State of Metal After Melting	Kw.-Hr. per Ton to Melt	Metal Loss in Melting
Copper	Electrolytic cathode Pig Scrap, heavy Scrap, light Scrap, dirty Chips, oily Chips, clean	Pig at pitch without rabbling or poling Wire bar Foundry castings	300 to 500	No oxidation; a certain amount of copper oxide is reduced
Zinc	Electrolytic cathode Pig Punchings Chips Heavy scrap	Pig Foundry castings Billets for rolling Battery electrodes	90 to 120	Dross and oxidation under 2 per cent
Nickel	Shot Bar Scrap	Pig Foundry castings Billets for rolling	500 to 750	No oxidation loss
Aluminum	Pig Scrap Punchings Turnings	Pig Foundry castings Billets for rolling	400 to 750	Less than 1 per cent oxidation
Tin	Bar Pig Scrap	Bar Pig Wire	40 to 60	No oxidation
Lead	Pig Scrap Sheet	Billets for rolling Casting Pig	20 to 40	No oxidation

Fifth Source of Melting Loss

Speed of Melting. The loss of zinc is proportional to the temperature and length of time the metal is held at the high temperature. This statement means that if you melt one charge at the rate of 100 lb. per hr., and a second charge at the rate of 200 lb. per hr., all other conditions being the same, the melting loss of the second charge will be less than that of the first charge. Electric methods of melting lend themselves to much quicker melting or higher melting rates than with fuel-fired furnaces.

Determination and Measurement of Metal Loss

Metal loss in melting is ordinarily best judged from chemical analysis of the metals charged. This test eleminates errors arising from furnace walls, absorption or the reverse, and also the losses in pouring.

To show the inconsistency of the actual recovery method of loss test, results of comparative tests on coal-fired crucible furnaces and electric furnaces are given in Table IV. Crucible capacity 250 lb. Electric furnace capacity 1500 lb. The metal was poured from the crucible directly, whereas an auxiliary ladle was used to pour the 1500 lb. from the electric furnace, thus giving chances for greater loss in pouring.

Tables VII, VIII and IX show the average performance to be expected from the use of the electric furnace, with the furnace charge in different physical form, etc. Table X shows like results for fuel-fired furncaes.

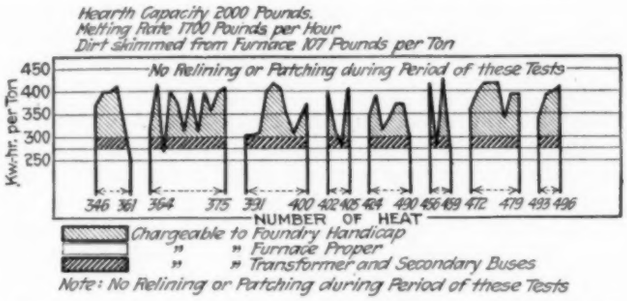

Hearth Capacity 2000 Pounds.
Melting Rate 1700 Pounds per Hour
Dirt skimmed from Furnace 107 Pounds per Ton
No Relining or Patching during Period of these Tests
Kw.-hr. per Ton
450
400
350
300
250
346 361 364 375 391 400 402 405 424 490 458 469 472 479 493 496
NUMBER OF HEAT
Chargeable to Foundry Handicap
" " Furnace Proper
" " Transformer and Secondary Buses
Note: No Relining or Patching during Period of these Tests

FIG. 6. POWER REQUIRED FOR MAKING RED BRASS FROM DIRTY SCRAP IN ELECTRIC FURNACE

TABLE VIII. NON-FERROUS ALLOYS MADE IN ELECTRIC FURNACE

Metals	Condition of Metal Charge	State of Alloy After Melting	Kw.-Hr. per Ton	Metal Loss, Per Cent
Red Brass				
Cu 80 Zn 10 Sn 6 Pb 4	Scrap pig, electro. cathodes Scrap bar Scrap pig	Foundry castings Wire bar Billets	250 to 400	0.25 to 0.75, depending upon manipulation of furnace
Yellow Brass				
Cu 60 Zn 39.5 Pb 00.5	Scrap, pig, electro. cathodes Scrap, pig	Foundry castings Wire bar Billets for rolling	220 to 350	0.50 to 1.5

TABLE IX

Alloy	Condition of Alloy Charged	State of Alloy After Melting	Kw.-Hr. per Ton	Loss per Cent	Alloys Temp. Deg. C.
Red Brass	Yellow brass and copper or red brass and zinc, pig scrap and sprues, turnings and chips	Foundry castings Wire bar Billets	225 to 300	0.15 to 0.50	1300
Yellow Brass	Red brass and zinc or yellow brass and zinc, pig scrap sprues, turnings and chips	Foundry castings Wire bar, Billets	200 to 275	0.40 to 1.00	1100
Monel	Copper nickel Scrap and billets	Foundry castings, Billets	500 to 750	No oxdation	1600
Aterite	Cu sprues, scrap Ni virgin metal Zn	Foundry castings, Billets for drawing and rolling	500 to 750	2% Zn, loss out of 32 per cent	1650

TABLE X. AVERAGE MELTING RESULTS, REALIZED IN THE AVERAGE FOUNDRY WITH FUEL-FIRED FURNACES

Type	Furnace Draught	Fuel, Kind	Per Ton	Metal Loss	Red Brass, Low Zn, 10 per Cent and Less Yellow Brass, High Zn, More Than 10 per Cent
Pit	Nat.	Coke	1400 lb. 1000 lb.	3.5 5	Red brass Yellow brass
Pit	Forced	Coke	700 lb. 600 lb.	1.5 2	Red brass Yellow brass
Tilting	Forced	Coke	600 lb. 400 lb.	1.5 2.8	Red brass Yellow brass
Pit	Nat.	Coal	1200 lb. 700 lb.	3.5 5	Red brass Yellow brass
Reverb.	Nat.	Coal	900 lb. 400 lb.	6.2 1	Red brass Yellow brass
Pit	Bumers Tangential	Oil	50 gal. 40 gal.	1.5 3	Red brass Yellow brass
Tilting	Open flame Atomizing Bumers	Oil	60 gal. 45 gal.	2.2 3.5	Red brass Yellow brass
Tilting Crucible	Bumers Tangential	Nat. gas	4800 cu.ft.	2.75	Yellow brass
Tilting Crucible	Bumers Tangential	City gas	7000 cu.ft.	2.75	Yellow brass

The results given in the tables are average figures and will be influenced to meet any particular foundry by

(a) Promptness of pouring.

(b) Temperature.

(c) Local conditions, such as physical condition of metal charged, its cleanliness, volume of air and products of combustion which pass through the furnace in natural draught furnaces.

This varies from day to day, depending on the weather.

(d) Design of furnace.

(e) Manipulation of furnace.

(f) Size of crucible.

(g) Percentages of composition.

(h) Length of working day.

(i) Whether observations are based on hot furnace and hot crucibles or whether the first heat of the day is excluded.

(j) Whether pouring light or heavy castings. Pouring light castings requires hot metal, and pouring heavy ones requires metal at lower temperature.

(k) Whether results are from careful tests or whether they represent actual foundry or rolling mill practice and extend over a considerable period.

Curve sheet (Fig. 6) illustrates how the furnace which is able to turn out metals for 300 kw-hr. per ton requires in reality an average of 350 kw.-hr. per ton due to foundry handicap.

Conclusion

In conclusion, the chart, Fig. 7, shows the excess cost for melting brass, and is made up from curves and tables preceding it. It is assumed that all the brass in the country is melted, (1) in fuel-fired furnaces, all types being employed equally; (2) that the same work

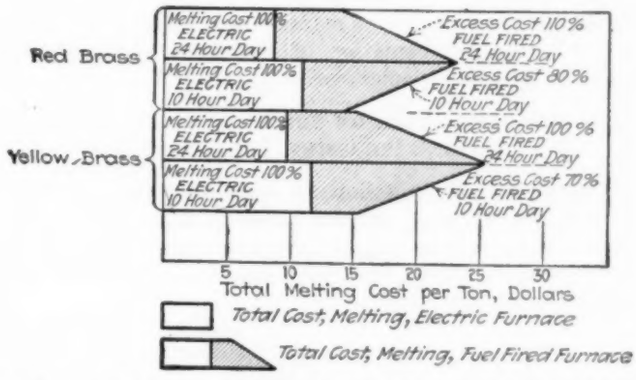

Red Brass
Yellow Brass
Melting Cost 100% ELECTRIC 24 Hour Day
Excess Cost 110% FUEL FIRED 24 Hour Day
Melting Cost 100% ELECTRIC 10 Hour Day
Excess Cost 80% FUEL FIRED 10 Hour Day
Melting Cost 100% ELECTRIC 24 Hour Day
Excess Cost 100% FUEL FIRED 24 Hour Day
Melting Cost 100% ELECTRIC 10 Hour Day
Excess Cost 70% FUEL FIRED 10 Hour Day
5 10 15 20 25 30
Total Melting Cost per Ton, Dollars
Total Cost, Melting, Electric Furnace
Total Cost, Melting, Fuel Fired Furnace

FIG. 7. CHART SHOWING EXCESS COST MELTING BRASS

is done in the electric furnace. The cases of red brass and yellow brass have been considered. Four conditions are shown, viz.: 10-hr. day—(1) melting yellow brass, (2) melting red brass; 24-hr. day—(3) melting yellow brass, (4) melting red brass.

The shaded portion of each wedge shows the saving in total cost between melting with fuel and with electricity. This chart stated in words and figures is as follows:

Furnace	Alloy Melting	Length Working Day, Hr.	Per Cent Saving Over Fuel-Fired
Electric	Yellow brass	10	100
Electric	Red brass	10	80
Electric	Yellow brass	24	110
Electric	Red brass	24	70

These margins of savings are of such magnitude that we cannot longer doubt that the electric furnace is destined to dominate completely the brass-melting field.

Potassium Permanganate From Ferromanganese by Electrolysis

By M. deKay Thompson

THE fact that permanganate is produced by the electrolysis of manganese or ferromanganese anodes in alkaline solutions was first recorded by R. Lorenz (*Z. f. anorg. Chem.*, vol. 12, p. 393, 1896) in a brief notice which gave no further information than the statement above. The anodic behavior of manganese in solutions of sodium sulphate alone and with additions of sodium hydrate, and in solutions of acid sodium phosphate (NaH_2PO_4), with and without additions of sodium hydrate, is the subject of part of an article by W. J. Müller (*Z. f. Elektrochem.*, vol. 11, p. 755, 1905). His principal result is that hydroxyl ions produced passivity, as shown by potential measurements.

A study of ferromanganese anodes in caustic soda solutions was made by G. R. White (*J. Phys. Chem.*, vol. 10, pp. 502-513, 1906). This paper, however, is largely taken up with a discussion of the reduction of permanganate to manganate in alkaline solutions, and scarcely any electrochemical data are given. The anode current densities were 2.5 to 12.5 amp. per sq.dm., the temperatures from 20 deg. C. to 95 deg. C., the concentrations 2 to 10 per cent. The maximum current efficiency was 12 per cent (under what conditions is not stated).

C. J. A. Griner patented the process of making permanganate by the electrolysis of manganese carbide anodes in concentrated sodium hydrate (German patent 125,060, July, 1900). It is claimed that manganese carbide anodes are superior to ferromanganese, as it is stated ferromanganese anodes have to be cleaned frequently on account of the formation of manganese dioxide, and also the yield with these is low. This patent evidently has no value, as manganese carbide decomposes water with the formation of hydrogen and methane. (Roscoe and Schorlemer, vol. 2, p. 1155.)

Experimental Work on the Electrolytic Method of Making Potassium Permanganate

The object of the following work (carried on in the spring and summer of 1918) was to see whether this method of making potassium permanganate could be used commercially. The ferromanganese used had the following composition:

	Per Cent.		Per Cent
Manganese	75.1	Silicon	0.9
Iron	16.7	Phosphorus	0.2
Carbon	6.1		
		Total	99.0

It also contained copper, nickel, calcium, magnesium, and arsenic.

Small-scale experiments with a solution of potassium hydrate containing 24 g. per 100 cc., with an anode current density of 20 amp. per sq.dm. (180 amp. per sq.ft.) at 45 to 50 deg. C. showed that the electrolysis proceeded for a few hours with a current efficiency of 15 per cent, but that there was a coating of oxides formed on the anode, which gradually protected the metal beneath from the further action of the current. An attempt to overcome this by using a pulsating current was not successful.

On replacing the hydrate solution by a 20 per cent carbonate solution no further trouble was encountered by the scale protecting the metal, other conditions remaining the same.

On a subsequent occasion, when the hydrate solution was used again, the anode was not attacked, but gas was evolved instead. This would appear to be a case of passivity, which was doubtless due in part to the hydroxyl ions. Why it appeared in this case and not in the first experiments is not clear.

Experiments in Large Cell

The next step in the evolution of this process was to try it on a semi-commercial scale. A cast iron plater's tank of the following inside dimensions was used: at top, 53 x 33 cm., at bottom 47 x 26 cm., and 38 cm. deep. A wooden pattern 2 cm. thick, of the shape of an anode used in copper refining, was made, and several attempts were made at casting anodes in a closed sand mold. The metal was melted in a Dixon graphite crucible in a pot furnace, requiring about four or five hours. It poured and filled the mold, but the metal always cracked on cooling. It was found subsequently that this could be prevented by cutting vertical slots in the pattern, but the anodes used in this tank were made by casting bars of the metal in open sand molds, and attaching these to an iron crosspiece. They were not annealed. A hole was left in one end for a bolt. The dimensions were 2.5 x 5 x 36 cm. The cathodes were sheet iron, the diaphragms asbestos cloth bags, the edges held together by bent iron strips. On account of the expense, the quality of the asbestos was not as good as that used in the small-scale experiments, and holes could be seen in it on holding it up to the light. An attempt was made later to improve the diaphragms by painting them with some of the anode mud. There were five anodes and six cathodes. The experiments were not successful, because the cell heated up to 70 deg. C. from the passage of the current and this caused a layer of oxides to form on the anode, which prevented electrolytic attack, as in the case with hydrate solutions. The electrolytic tank was then placed in a tub through which tap water circulated. This kept the temperature down to 40 deg. C. and there was no further difficulty and the anodes never needed cleaning. The current used was limited by the temperature of the tap water, which allowed only a limited amount of cooling. In the following runs the full number of anodes was not always used because of breakage. The current density was approximately 7 amp. per sq.dm. (65 amp. per sq.ft.) at about 4.2 volts, and the total current about 350 amp. The concentration of potassium carbonate was maintained at about 200 g. per liter. The volume of electrolyte was about 35 liters. The electrolysis lasted only from 9 a.m. to 9 p.m. and the cell stood idle over night. After electrolyzing four or five days, the liquid and anode mud were removed and heated to about 90 deg. C. to cause all permanganate crystals to dissolve. The liquid was then filtered through a large asbestos filter under suction, and the filtrate was allowed to crystallize. The anode mud was removed from the filter, was washed several times with hot water and the wash water added to the main solution, but it would have required many washings to get the mud free from permanganate and carbonate. Even after four washings crystals of permanganate would appear on the surface of the mud on drying. This suggested the idea that it would be more efficient to allow the mud to dry before the final washings, and while no accurate data were obtained to confirm this point, this procedure did seem to give better results.

On cooling, the mother liquor was drained off and the

crystals centrifuged with a little washing by sprinkling. They analyzed over 98 per cent pure. Approximately 40 lb. was made during these experiments.

RESULTS WITH LARGE CELL

No.	Amp.	Amp. Hr.	Kg. $KMnO_4$ Produced	Per Cent Current Eff.	Kw.-Hr. Per Kg.	Per Cent Mn Converted to $KMnO_4$	Loss in Weight of Anodes, Kg.
2	350	17,370	1.68	11.0	44	....	....
3	350	16,000	2.00	17.6	32	....	....
4	350	21,200	3.84	21.6	25	....	....
5	350	18,880	2.79	18.6	30	34.5	3.78
6	350 to 400	19,820	2.15	13.2	40	62.5	2.1
7	350	21,330	3.42	19.2	28	62.5	2.52
Average				17.0	33		

The total anode mud made weighed 21.5 kg., the permanganate 20.7 kg. A considerable portion of this mud was found in the cathode compartments, showing that permanganate diffused through the diaphragm and was reduced. This would occur to a less extent with better diaphragms, and would increase the current efficiency.

It was found that the anodes were attacked very much more near the surface of the electrolyte than at the lower end, evidently on account of relatively poor electrical conductivity of this alloy. It would therefore seem advisable to cast the anodes with a taper toward the lower end.

These experiments sufficed to determine only the cost of materials and power for the manufacture of potassium permanganate. These are the following, assuming the ferromanganese to cost $260 per 2240 lb., power $20 per hp.-yr., and 85 per cent potassium carbonate 40c. a lb.:

Required for 1 lb. of potassium permanganate:

1 lb. ferromanganese	$0.12
15 kw.-hr.	.05
0.52 lb. 85 per cent K_2CO_3	.21
Total	$0.38
For 1 kg. the cost would be	$0.84

Other expenses of this manufacture which would have to be determined by a small experimental plant are: Cost of casting anodes, cost of installation, labor, etc. The anode mud, consisting of oxides of iron and manganese, could doubtless be sold for something.

Since writing the above an article on sodium permanganate by Wilson and Horsch[1] has appeared.

The results of their work differed from those above in that the higher current efficiency of 35 per cent was obtained, and 7 volts per cell were used. Perhaps the most important difference is that the anodes had to be cleaned by sand-blasting every 24 hr. In order to see whether this was due to using sodium carbonate in place of potassium carbonate, the original anode used by me was tested in sodium carbonate, without cleaning since last used in potassium carbonate.

The results were the following:

G. Na_2CO_3 per 100 cc.	15.7	Amp. per sq. dm.	5.2
Duration, hr.	85	Amp. hr.	254
Temp. deg.	40	Per cent current eff.	20.5
Volts	4.2	Per cent Mn converted to MnO_4	66

The run was continuous for 3, 26, 27 and 30 hr., but the anode was not cleaned at any time. This shows the lack of necessity for cleaning the anode is a property of the anode, as it behaves the same in sodium carbonate as in potassium carbonate, at this temperature.

Some ferromanganese used by Wilson and Horsch, which required periodic cleaning when used as anode, was analyzed, with the following result:

Manganese	78.5	Silicon	1.2
Iron	13.8	Phosphorus	0.2
Carbon	6.8		
		Total	100.5

The principal difference between this alloy and that used in the above work is that this contained about 3.5 per cent more manganese and a corresponding less amount of iron. This would hardly seem to be sufficient to account for the different anodic behavior, but in order to test this point an anode was made by melting some of the 78.5 per cent ferromanganese with the calculated amount of steel turnings to make 75 per cent ferromanganese. This anode was not analyzed, so the composition may not have been exactly that desired. This anode electrolyzed for a longer time without requiring cleaning, but eventually the voltage did rise and the scale had to be removed before the electrolysis could be continued. This merely indicates that the anodic behavior of ferromanganese is quite sensitive to its composition.

The author hopes to resume this investigation later, but as the work has to be discontinued for the present, it is not considered advisable to delay further the publication of the results obtained.

SUMMARY

These experiments show it is possible to manufacture potassium permanganate from commercial ferromanganese, containing about 75 per cent manganese, by electrolysis in a potassium carbonate solution without the necessity of ever cleaning the anodes. The temperature must not be allowed to rise much above 40 deg. C., for if it does an insulating coating of oxides is formed, which prevents the production of permanganate. Carbonic acid is not lost in the electrolysis. The current efficiency was about 17 per cent, but it would be higher with better diaphragms. The current density was 65 amp. per sq.ft. The anodes are attacked more at the top than at the bottom.

The anodic behavior, as regards formation of insulating scale, is affected by a small change in the relative amounts of iron and manganese in the anode.

Massachusetts Institute of Technology,
Cambridge, Mass.

[1] *Trans.*, Am. Electroch. Soc., April, 1919.

Short Course in Ceramic Engineering

The Department of Ceramic Engineering of the University of Illinois is engaged in making preparations to give a two-weeks short course in ceramic engineering in February, 1920. This short course will follow in general the same lines as the short course given in 1918, and will include lectures and laboratory work in the physics and chemistry of ceramic materials and processes; mining, sampling, handling and testing of clays; shaping, drying and burning; machinery and equipment for the ceramic plant; refractories, glass, glazes, etc. The complete program of the course will be sent free to all who apply for it. The course is open to any person interested.

Explosive Plant at Nitro Sold

After some negotiation with bidders the Government has sold its explosive plant at Nitro, W. Va., to the Charleston Industrial Corporation of Charleston, W. Va. The figure agreed upon was $8,551,000.

Industrial Magazines and Labor Conditions*

By Harry E. Cleland

IN JULY and August of this year there was an average of 336 strikes going on daily in the United States.

In the general fog there are at least two things clear: First, that there has been a pronounced and progressive decline in production. Second, that shorter hours and higher wages have not been compensated for by increased efficiency.

That portion of capital and management which regards labor as a commodity to be bought and sold, hired and fired must come out of its comotose condition. And that portion of labor which looks upon capital as an arch enemy and which is ruled by its radicals must throw the hobgoblin to the scrap heap and consign the swashbucklers to the same place.

Capital cannot afford to be reactionary. Labor cannot afford to be revolutionary.

There must be a real partnership before there can be a true industrial democracy. Fundamentally, real partnerships are based upon mutual confidence. Labor unrest is the result of a lack of such confidence.

Labor thinks that its cravings will be satisfied with more money. That is not true. Capital thinks that all that labor wants is more money and certainly labor does everything to give capital that idea. That, too, is untrue.

Labor wants a decent living wage based on what it produces plus as much interest in the things it produces as is possessed by the other hired men in the front office.

Business papers are the organs of industrial management in this country.

Labor Question Within Scope of Business Papers

It has been recognized for years past by the ablest business papers that the labor question as such comes within their sphere of activities. You will find that business papers as a rule have had and will have some constructive things to say on capital, management and labor, with the added advantage that they are not of necessity confined to the glittering generalities of the question but are able, because of their highly specialized character, to focus their comments upon the particular labor problems of the single industry they represent.

In the new light of things they will recognize fundamentally that capital and management are very seldom one and the same thing. Management is usually a hired man exactly as is any other worker in the plant.

And business papers will write it down as a basic principle that management must manage not only for the interests of capital but for the interests of labor as well. Otherwise its job is poorly done for both parties to the transaction.

Business papers, I believe, must point out clearly to their readers that a new industrialism is at hand. They must show that capital, management and labor are infested with certain fallacies and that these must be removed before any basis of mutual understanding can be reached.

It is a fallacy on the part of labor to say that production must be curtailed and that labor-saving machinery must be fought in order to make more work for more people.

It is a fallacy for labor to believe that it is the sole creator of wealth. The products of industry are only partly the work of labor.

It is a fallacy for labor to believe that the objects sought by capital are opposed to the objects sought by labor.

It is a fallacy for management to assume that it is accountable only to capital.

It is a fallacy for management to regard labor as a commodity to be bought and sold according to the law of supply and demand.

It is a fallacy for capital to contend that it is the sole factor because it supplies the funds.

It is a fallacy for capital to assume that it has no responsibility beyond supplying the funds.

It is a fallacy for capital to contend that all profits belong to it.

Papers Should Expose All Profiteering

I believe that business papers must expose to the light of publicity every flagrant case of profiteering it finds whether it be on the part of capital or labor. The man who pays $18 a ton for pig iron and sells it for $55 is a profiteer. The worker, who, having received advances amounting to nearly 75 per cent in two years, now demands—as New York printers are demanding—an immediate further increase of 65 per cent, is a profiteer plus. Certain elements of labor are howling to high heaven about the pitiless profiteers, but when it comes to sheer and unadulterated arrogance in profiteering, I commend you to the average insurgent union which, having broken loose from the wiser counsel of its international leaders, runs its rampant ruining race.

Business papers must report the progress, success or failure of all attempts on the part of capital, management and labor to form industrial democracies within the individual plants. They must show plainly why such attempts succeed or fail. Already there is a wealth of material. The pioneering of such concerns as the Colorado Fuel & Iron Co., the Midvale Steel & Ordnance Co., the International Harvester Co., Hydraulic Pressed Steel Co., the Multigraph Co. and many others is a matter of vital importance to every man, woman and child in the country.

Business papers should advocate that capital choose its managers on a basis first, of their ability to handle men, second, of their technical skill. The reverse has been the rule. And the reasons for this are so apparent that why any other course should have been chosen will remain a mystery always.

Why is it that one concern pays its men an average of $38 a week and gets unswerving loyalty and full production while another in the same locality pays an average of $41 a week, has labor trouble continuously and never reaches full production? It is because the manager of the first concern treats the workers like human beings, makes a point of knowing them personally, takes them into his confidence, and makes their shop life something more than a daily grind, while the other tries to cultivate loyalty with a slide rule and a micrometer.

Loyalty—and loyalty means production—is only incidentally a matter of money and hours; loyalty is

*Abstracts from a paper read before the Associated Advertising Clubs of the World, New Orleans, September, 1919.

a matter of mind and heart, and you can't produce it by any strong-arm methods—to get, the concern must give.

The Open Shop Advocated

It is also my belief that business papers should advocate the open shop.

The closed shop is un-American, and nothing un-American should be tolerated for a minute. Every American is born with or inherits the right to say where he shall work. Every American employer has the right to say whom he shall hire.

The closed shop tends to put all workers on the same dead level of mediocrity, throttles individuality, stifles initiative, curtails production and destroys the dignity and power of labor.

The opportunity for individual initiative, the possibility for any workman to become a master, has made this country what it is in manufacturing and all other industries.

The closed shop means the changing of all this to the foreign standard, where a workman is always a workman, where ambition is still-born and hope is dead.

The open shop means the freedom of every man to do what he thinks best for himself, provided he does not encroach upon the liberty of others.

This imported closed shop, that prevents young men from learning the trade; that restricts output; that keeps improved machinery products down; that forbids the owner of the plant from having his own foreman or any other representative in the workroom, is in itself wrong. It is against the liberty of men. It is slavery. It cannot be tolerated in a free country.

Causes of Labor Trouble

I said awhile ago that business papers ought to look into the causes of labor trouble and seek a remedy.

One of the principal causes of labor trouble is the reduction in piece rates.

If the worker on piece rates does exceptionally well and makes big money he is afraid, and usually justifiably, that his rate will be cut. In those circumstances, he produces just enough to make what seems to him will correspond to his possible maximum wage.

For instance: A boy in a New England factory was tapping nuts at a piece rate of 10 cents a hundred. His average production was 3000 nuts per day. One day he overheard the superintendent tell his foreman that the concern had decided to quit making that particular kind and size of nut. In that one day the kid tapped 8200 nuts!

No matter whether the employer pays by bonus, differential piece system, premium or what not, he must play fair if he expects full production. Business papers must advocate the square deal.

Now let us find out as nearly as we can what the sentiment of business in this country is on the labor question.

Sentiment of the Country as Polled

The United States Chamber of Commerce submitted 13 principles of industrial relations to the vote of its member organizations representing business associations of all kinds. Capital and management did this voting, mind you, not labor.

Four hundred and thirty-three organizations filed ballots in 44 States, the District of Columbia, Alaska and Hawaii. The vote was overwhelmingly in favor of 12 of the principles, and the Chamber of Commerce is now committed to the following:

1. Industrial enterprise, as a source of livelihood for both employer and employee, should be so conducted that due consideration is given to the situation of all persons dependent upon it.

2. The public interest requires adjustment of industrial relations by peaceful methods.

3. Regularity and continuity of employment should be sought to the fullest extent possible and constitute a responsibility resting alike upon employers, wage earners and the public.

4. The right of workers to organize is as clearly recognized as that of any other element or part of the community.

5. Industrial harmony and prosperity will be most effectually promoted by adequate representation of the parties in interest. Existing forms of representation should be carefully studied and availed of in so far as they may be found to have merit and are adaptable to the peculiar conditions in the various industries.

6. Whenever agreements are made with respect to industrial relations they should be faithfully observed.

7. Such agreements should contain provision for prompt and final interpretation in the event of controversy regarding meaning or application.

8. Wages should be adjusted with due regard to the purchasing power of the wage and to the right of every man to an opportunity to earn a living at fair wages, to reasonable hours of work and working conditions, to a decent home, and to the enjoyment of proper social conditions.

9. Fixing of a basic day as a device for increasing compensation is a subterfuge that should be condemned.

10. Efficient production in conjunction with adequate wages is essential to successful industry. Arbitrary restriction on output below reasonable standards is harmful to the interests of wage earners, employers and the public, and should not be permitted. Industry, efficiency and initiative, wherever found, should be encouraged and adequately rewarded, while indolence and indifference should be condemned.

11. Consideration of reduction in wages should not be reached until possibility of reduction of costs in all other directions has been exhausted.

12. Administration of employment and management of labor should be recognized as a distinct and important function of management and accorded its proper responsibility in administrative organization.

13. A majority was in favor of the thirteenth, which had to do with national employment offices, but it did not receive the required two-thirds vote.

Doesn't the action of the Chamber of Commerce look as if the spirit of fair play were abroad in the land?

There will always be differences of opinion, but they need not lead to riot and rape, bloodshed and murder, closed factories and open almshouses.

Fair play and co-operation fully exercised between capital and labor is after all a sovereign remedy for the ills of both. Co-operation saved the world. It can save this situation.

America's Case in Chemistry*

By Ellwood Hendrick

TOWARD the end of the eighteenth century, and in the beginning of the nineteenth, there were in this country distinguished and active contributors to research in chemistry. We have but to read the charming biographies of that delightful savant Dr. Edgar S. Smith, provost of the University of Pennsylvania, to appreciate not only the scholarship attained by such men as James Woodhouse, Robert Hare, Benjamin Silliman and others, but also their very considerable gifts to the common store of knowledge and understanding. It will be recalled that in those days Joseph Priestley, having discovered oxygen in England, came to America, not only to enjoy freedom of worship, but, being Unitarian in religious disposition, in order to avoid in a literal sense the brickbats of orthodoxy. To the end of his days Priestley held to the theory of phlogiston. It was an idea fixed in his mind that every dancing flame was a manifestation of the escape of this imaginary body, except when the ash weighed more than the burned substance. Then phlogiston was assumed to reverse itself and go backward. Woodhouse was modern in his views of combustion, championing those we hold today, following Lavoisier in France, and Klaproth in Germany. He had a doughty opponent, and, since Priestley spoke with great authority, the battle waged long and fierce, till the Englishman cried quits, although he remained unconvinced to the end of his days. I know of no more illuminating sidelight to throw upon the quality of the men at that time engaged in science in the United States than to point out that whenever Priestley was attacked on any other ground than that of the scientific heresy of phlogiston, Woodhouse would rush to his aid, supporting him in all his dignity as a great philosopher in science. Then, for a long time, chemistry seemed almost forgotten.

Franklin's Aid to Science

As a reason for this I venture to propose that in our earliest days as a nation we had a world figure in Benjamin Franklin, who was intensely interested in science, to aid us. It was he who advertised research in physical science in America. Now business men know the value of advertising. If they sell goods in packages with a trade mark, and can get this trade name sufficiently talked about, they can dispose of their product in vast quantities, and at a higher figure than the market price for the same goods. Other merchants may hold vast stocks of the identical wares and be unable to find a market for them. In later years scientific achievement in this country was sporadic, the contributions came from men born to their work, while recognition was infrequent and difficult to obtain. Joseph Henry would have been the master of physics that he was under any circumstances, but even today we do not accord him the full honor to which he is entitled. Simon Newcomb would have been a great astronomer whether he went to Washington or not, and Willard Gibbs worked in utter loneliness because his own colleagues did not appreciate or even understand him. Unlike the model child who may be seen but not heard, the man of science may be neither seen nor heard while engaged at his task. And afterward his findings are likely to be recorded in language almost cryptic, so that whatever rewards attach themselves to his name seldom reach him during his lifetime. Or if they do, they lack the trumpet-and-drum quality that appeal to us in youth while we are determining what career we shall pursue.

Had Abraham Lincoln or Theodore Roosevelt been a chemist the profession of chemistry would have had a far higher standing in this country than it has enjoyed. It would not have got out of focus. Even in public pronouncements these men, whose every word had news value, would have employed the illuminating chemical similes which are now slowly finding their way into the public consciousness.

The profession, I repeat, was out of focus. We did not have chemists enough because the subject was not talked about enough. Now, the special bent of brilliant minds is not always disclosed in youth. They have to feel their way along until they strike their *metier*, and it goes without saying that many a brilliant mind would have addressed itself to chemistry had the subject enjoyed the general consideration which is warranted by its importance. Chemistry was, in fact, a learned profession long before the tradition lost weight that law and divinity were the only suitable callings for a thoughtful man.

War Revealed Importance of Chemistry

When the great war came upon us the eyes of the people were opened. Chemists were suddenly needed, needed as never before—and how ours responded the world knows. We should not let the occasion pass without mentioning the ringing appeal of Dr. Julius Stieglitz of Chicago, then president of the American Chemical Society. Dr. Stieglitz knew neither rest nor sleep until he had sounded the country's resources in chemists and, with Dr. Parsons and the Bureau of Mines, had completed the rapid census of available men. We must note the competent organizing ability of Dr. W. H. Nichols that was called into play, and the forward march to Washington of chemical manufacturers who placed all their possessions at the service of the Government. Nor must we forget the organization of the Naval Advisory Board, and the earnest, constant and weighty contributions of such men as Willis R. Whitney and Leo H. Baekeland, the American University and its passionate tension of work in research, the seven-league boots in which W. H. Walker strode to production at the Edgewood Arsenal, the great work of by far too many of our leaders in chemistry even to name them in passing, and the thousands of glorious young men who rushed in from universities and laboratories, the country over, and threw themselves into the mighty effort. It was great, it was magnificent, and it showed the spirit of America as surely as this was shown by our soldiers on the battlefield. Neither did the Chemical Warfare Service fail. Working together with the British and the French under General Fries, it was ever on hand, the laboratories co-ordinating with the front, stubborn in defense, valiant in attack, until victory was won. It is a glorious record.

But here again we need the Voice of Authority in council. We lack our Benjamin Franklin to whom public opinion and men in office will give heed. We have no one who speaks with the Voice of Authority in science to the types of mind represented, for in-

*Paper read at the Fifth National Exposition of Chemical Industries, Chicago, Sept. 23, 1919.

stance, in the Congress of the United States. We have the men, and these men can speak, but Congress will not listen. Neither will others who also should give heed.

The fact is brought home to us by the passing of the Chemical Warfare Service. This organization provides a means of overcoming an unprepared enemy without loss of life even, since, by proper use of lachrymator or other gases, enemy soldiers may be put *hors de combat* and taken prisoner *en bloc*, and yet they recover in a few hours, fully restored to health. We have learned that, given on the one side chemical preparedness, and unpreparedness on the other, the army thus scientifically equipped is almost certain to win, while the unprepared opponent is equally likely to lose. After the Germans launched their first chlorine attack against an unprepared enemy the Channel ports were wide open to them, and why they did not take them is still unexplained. This first attack with gas was an ethical breach, the responsibility for which will always rest with the Germans, but when the convention had been broken and gas came into use, it straightway became a recognized instrument of warfare, employed by all.

Use of Gunpowder Once Considered Unsportsmanlike

It was started, just as once upon a time the use of gunpowder was started. The early introduction of shooting an enemy beyond the range of the bow and arrow was condemned as unsportsmanlike, and it *was* unsportsmanlike. It is far more valiant and manly in every way to meet an enemy face to face, sword in hand, in battle array, and fight it out with him in the open, than to murder him unawares. But the advantage rested with gunpowder, and accordingly gunpowder remains in use. We have also learned that if both sides are prepared and equipped, then chemical warfare is the most humane method of fighting yet devised, and that, while it kills, it leaves hardly any soldiers maimed or seriously incapacitated. As for the argument that chemical attack may be carried so far as to blot out entire nations, this may be an argument against war in any form, and in favor of a League of Nations, but it will not prove a deterrent to the nation that is using it. Wars usually occur as the result of some breach of convention or of promise. And even if we establish the convention that chemical warfare shall be forbidden, none the less we should keep ourselves at all times fully informed concerning it. Otherwise we are placing our country and our people at the mercy of any power that may see fit to break its word. So we chemists hold that the work done in providing this instrument for our army, and in organizing laboratories for service, offensive and defensive, in chemical warfare, should be maintained as a regular branch of our military system, whether we ourselves adopt the convention forbidding its use or not.

This has been said, and urged, and repeated, and printed, again and again, but the West Point traditions are stronger than our utterance, if not than our argument. The Chemical Warfare Service for the most part has been scrapped. It is about to be filed, rather than turned over to the Corps of Engineers—for there is hardly enough left to turn over—provided the present army reorganization bill now before the House is adopted. And even to-day to equip the Corps of Engineers with a competent chemical service would require, not only that much of the work be done over again, but that the Army should have something which the General Staff seems resolved not to have, and that is chemists!

Chemists Must Earn Recognition

The Voice of Authority is not achieved by cultivation. It does not depend on pitch, nor on tone. It must be earned rather than trained. But sometimes its failure to function is due to the deafness of the auditors, and it may be that the Great American Ear is not yet sufficiently attuned to the call of Chemistry to hear even so urgent an appeal as that our Chemical Warfare Service be retained. In the bill for the reorganization of the Army now before Congress, the plans for the distant future are rosy enough. A great institute for scientific research is provided as an additional part of the Corps of Engineers, but for the present we chemists hold that if research is to continue, it must remain a separate corps. We recall the amazing wastes in preparing for war due to the lack of understanding of chemical reactions by men in authority, and we fear that if chemistry is now made a subordinate department of the Engineers, it will cease to function. The chief of the division, whose time in days of peace is devoted to the improvement of rivers and harbors and the digging of canals, is likely to detail the least useful engineer officers to direct chemical research. And that will mean, so far as chemical warfare is concerned, defenseless America once more!

The Brighter Side

So let's take a hitch in our belts and look to the morning. We are doing pretty well in industry and teaching. In pure research we are holding our own, and the outlook is good. There have lately appeared the Langmuir Postulates in regard to the constitution of atoms and molecules that are epoch-making. The lucid explanations of the nature of the nitrogen molecule as compared with its atom, of the characters of the halogens and the alkali metals, of carbon monoxide, and of other problems, are vastly illuminating and helpful. The researches of Professor W. D. Harkins of Chicago, always interesting and worth while, the great authority among chemists the world over achieved by the work of Theodore W. Richards of Cambridge, Mass., the clear thinking of G. N. Lewis of California, the masterly accomplishments of Edward C. Franklin on the ammonia system of acids, bases and salts, the constant and repeated flashes of light thrown from the brilliant mind of Wilder D. Bancroft—only to mention a few of our masters whose work suggests itself in passing—all are indicative of the fact that the chemists of America are alive—alive and awake. It is theory and not a condition that confronts us in chemistry, and unless we are sound in our theories of chemistry we are bound to fail.

In regard to teaching, we have the men and we have the students. We also have an advantage that is peculiarly noticeable in this country: we work together in both pure and applied science. In other words, chemistry is ready for industry. On the other hand, we are somewhat careless in the training of the imagination and the requirements of general culture de-

manded of our students. This is no appeal for chemical snobbery; it is rather an appeal for recognition of the fact that the man of research needs a trained imagination. And in industry especially it is needed that the chemist be proficient in that greatest of the arts, which is the art of living. In industry he meets men whose lines have not fallen in pleasant places. Here are those who have not had a fair chance, and he can give it to them. The chemist represents the scholastics and philosophy of manufacture. He can contribute the guiding hand, the thoughtful advice, the pleasant leadings that never can be put into the pay envelope. It is in the factory that his culture, his scholarship and his grace of living are most needed. Nor are we as generous as we might be in rewarding our professors with money, or with that which is equally important, the honors that are warranted by their posts of influence.

Industry has taken notice of chemistry, but it has not yet completely wedded itself to science by availing itself of its opportunities. There is need of many more general commercial laboratories than can find support. We need more industrial research. Again, we have not yet learned the need of men with trained scientific minds on boards of directors of corporations engaged in chemical manufacture. This is a serious defect, and its results are frequently shown in the inertia of industry in failing to profit by improvements that would make for great economies as well as for advancement in well-being. Most of us are familiar with large industrial establishments, the processes of which are based on chemical reactions, and these corporations are operated from the standpoint of salesmanship, banking and law. The company's legal advisor sits in council to pass upon contracts and procedure in dealings with men, but the chemical advisor who understands materials, and who, therefore, is responsible for the company's products and its good repute, is generally left out in the cold. American industry at large, with only a moderate number of exceptions, is still deficient in its calls upon the man of science to its councils.

No Sole Reliance on a Tariff Wall

Whenever such calls are made the American chemist has responded and has set himself to work with diligence. That so many of his efforts have been crowned with success is pleasant to contemplate—but the way of progress does not lie in contemplation alone. We are in the race with the wide, wide world. In some respects we are ahead, and in others we are behind. We cannot lean back and fold our arms in the belief that a high protective tariff will assure us success. We must maintain the co-ordination between pure science and that which is applied. We must hold up the hands of our great teachers and encourage them in their arduous task. We must increase the honors and distinction of their offices, and make the post of teacher as desirable as possible. We must do what we can to discover the exceptional man, and to create opportunity for him, because often the exceptionally gifted in research lack the gift of finding places for themselves. We must preach the gospel of chemistry, and bear its evangel to spots where its light is still unknown. And we must, in one way or another, conjure up the Voice of Authority so that it may speak for us!

Let us borrow an example from Arthur D. Little to show how the Voice of Authority might aid us. The water flowing incessantly over Niagara Falls represents the same power, the same energy, as would be obtained by the burning of a prodigious amount of coal. Except for the cost of installation and the slight charges for maintenance, it would be possible to use the power of that falling water in exchange for a colossal coal bonfire, developing the same energy expressed in terms of heat, for the edification of visiting brides and bridegrooms. Let us imagine this done, with miners working, and trains rushing constantly day and night, to feed this unheard-of bonfire. Suppose the Voice of Authority could present this picture to the public so that all could visualize the thousands of men at work, and the immense capital represented in the cost of the coal and its transportation—and all of it going up in smoke! Suppose it were made clear that none of that coal is being used to propel ships to and from Europe and trans-ocean markets, nor to give us warmth, nor to drive the wheels of industry, but that it is being spent, simply to keep our huge, international bonfire forever burning, and that people are paying for this spectacle in the increased cost of living, while the tremendous fund of power goes to waste. With this fact made clear—that that falling water represents an equivalent in millions of tons of coal which are charged to the people of this generation, these same people would soon declare themselves in favor of taking profit from that inexhaustible power for the benefit of the two countries it lies between, for the benefit of ourselves and Canada!

Chemists Must Show Interest in Public Affairs

We need the Voice of Authority to put a stop to waste of power, waste of fuel, waste of wood, waste of materials and waste of labor—and waste of men! We need this Voice to point out to us the way of progress.

I believe that we can conjure it up, not as the utterance of one individual, nor in the shout of thousands of voices, crying in unison. It will come, but rather in the benediction of things done. I believe we can accomplish it if, as chemists, we interest ourselves intensely in public affairs, struggling with all our might, both individual and collective, for the public weal, by doing this daily, and without thought of personal reward. If we dig into public affairs with diligence, preaching the gospel of chemistry with all the ardor of insistence shown by the Ancient Mariner in telling his weird tale, then, in time, our message is bound to be heard and heeded. Indeed, then, with God's help, we may advance toward a greater enlightenment, with a better art of living, and in a better-ordered world, where justice and peace abide.

American Electrochemical Society Meetings

At the last meeting of the board of directors of the American Electrochemical Society it was decided to hold the next meeting in Boston, April 8, 9 and 10, 1920. The American Institute of Electrical Engineers meets about the same time and a joint session will be held on April 10 on the subject of electrically produced alloys. Another feature of the meeting will be a symposium on colloids under the direction of the president, Wilder D. Bancroft.

Heat Treatment of 155-mm. High Explosive Shell *

By William J. Merten

HEAT treating the 155-mm. shell had been the cause of worry and delay in production in almost every plant manufacturing this size and type of projectile. Consequently, when the Twin City Forge & Foundry Co. entered upon large-scale production, I was informed from all sides that the man responsible for the heat-treating practice had a real metallurgical job, and consequently I was naturally guarding against any of the things which my experience had taught me to avoid, so that we could get results right from the start.

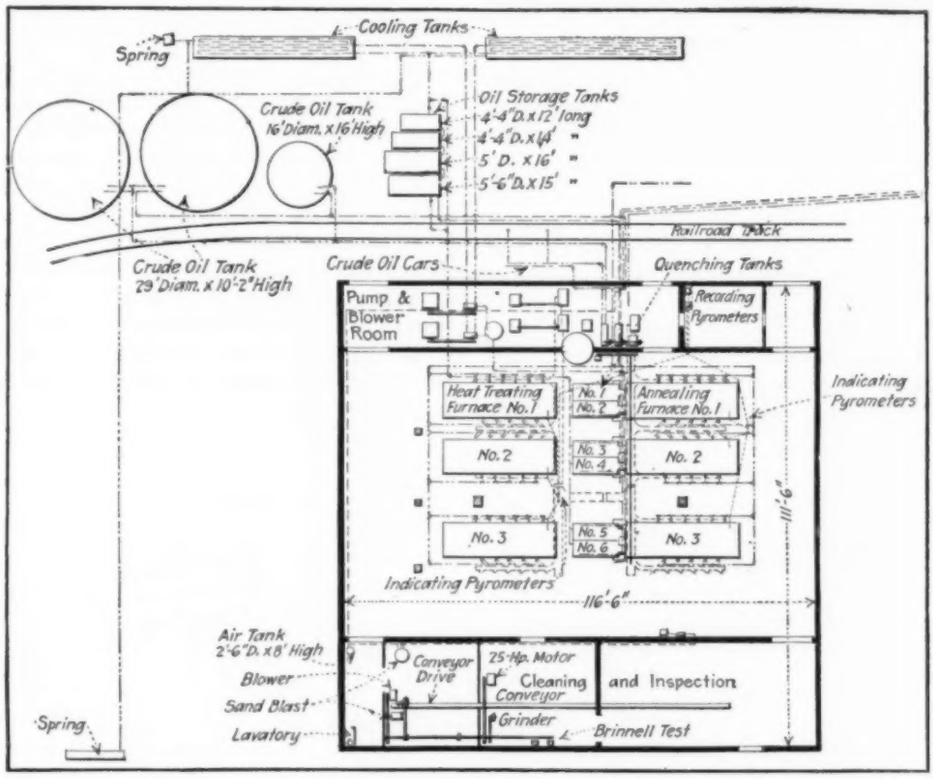


FIG. 1. PLAN OF HEAT-TREATING DEPARTMENT AND AUXILIARY SERVICES

After a very thorough deliberation with our engineering department the following described equipment and layout was decided upon:

Equipment and Layout

Three batteries of oil-fired Ferguson furnaces with inclined floor and perforated arch were installed, each battery consisting of one heat-treating and one annealing furnace set in tandem, with automatic quenching tanks between them. These furnaces were placed in an available building near a disused cupola as shown in the general layout given in Fig. 1. The only change in the design of the furnace as furnished by the maker was to interrupt the continuous slope of the furnace floor some 4 ft. from the discharge end. This horizontal bottom comprised in effect a soaking chamber, permitting a limited degree of freedom of movement of the shells within this portion of the furnace, so that the final adjustment and equalization of heat in the body of the shell might be made by rolling it into such a position that the darker or cooler part of the metal might be exposed or subjected to direct impingement of flame. To this seemingly small and unimportant change I attribute more influence toward our success in heat treating than to any other single item in the chain of improvements over the style of equipment ordinarily used heretofore. Especially was this of extraordinary advantage in the drawing furnace, since an even temperature as low as, say, 1250 deg. F. is rather difficult to attain unless the shell may be juggled without having the rest of the load follow along by gravity and eject the one from the furnace before it has become "evenly heated." This one item of "even heat" is unquestionably the most essential factor and requirement to give satisfactory results.

Design of Quenching Tank

In designing the quenching tank we attempted to incorporate several ideas. First, we wished to reduce to an absolute minimum any inactive bodies of oil within the container during the journey of the hot shell. Second, we expected that the passage of the shell and the operation of the elevator would accomplish a correct circulation of the cooling medium without resorting to other mechanical stirring. Third and finally, we expected to simplify the problem of correctly directing the cool incoming oil and pumping the hot oil from the other extremity of the surface. The guides for lowering the shell into the oil are so constructed that the stirrup or carrier receives the shell base down and releases it at a point where the curvature of the elevator frame pushes the base clear of its support (shown in the general cross section Fig. 3). Lugs on a traveling chain then up-end the shell so that it is finally deposited nose down upon the chain conveyor, which elevates the shell out of the quenching bath. It is driven by a sprocket wheel and delivers the drained shell on the

*As conducted at the plant of the Twin City Forge & Foundry Co., Stillwater, Minn.

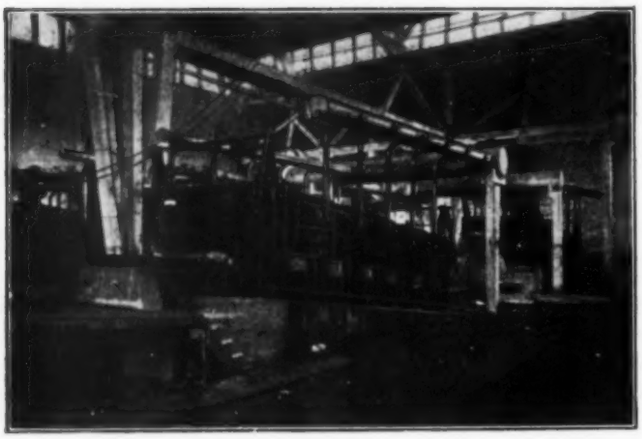


FIG. 2. OIL-FIRED HEAT-TREATING FURNACES

rear platform of the drawing furnace. This automatic tank successfully replaced not less than four men at each pair of furnaces at a point where the handling of hot metal is most inconvenient and difficult. The carriers are also provided with pockets to scrape up any scale from the bottom of the tank, dumping it upon a perforated shelf at the top of its travel, where oil is drained off and the scale may be removed.

Oil Circulation and Cooling System

The planning of our cooling system was influenced by a happy combination of natural advantages. Two springs within our premises delivered a constant flow of about 90 gal. of water per min. at a temperature of about 45 deg. F. The water from these springs overflowed into wooden cooling tanks and furnished the medium whereby we kept the temperature of the quenching oil at the proper point. In each of these cooling tanks were placed 1200 ft. of 2½-in. pipe, the tanks themselves holding some 1200 gal. of water, constantly circulating at the rate of 90 gal. per min., which was the amount of water delivered by the springs above noted. Oil flowed through the piping at the rate of 150 gal. per min. per battery of quenching tanks. Cooled oil was in this manner returned to the tanks at a temperature of about 140 deg. F. when running continuously 24 hr. per day, the cooling water reaching a temperature of 100 deg. F. at the discharge end on hot summer days. In order to cool one shell per minute from 1550 deg. F., the temperature at which it was delivered from the heat-treating furnace, to about 400 deg. F., the temperature when entering the drawing furnace, about 2000 gal. of oil were found to be necessary in the tanks themselves, and this quantity of oil should be circulated at a rate of 150 gal. per min. in order that the oil might not exceed a temperature of 150 deg. The oil, after being pumped through the cooling coils, emptied into a sump tank, from where it flowed by gravity back into quenching tanks. A separate pipe line and pump were used to empty the oil from the quenching tanks into storage tanks. An analysis of the above data shows the following:

Having a good quenching medium (in this case Houghton Soluble No. 2) a bath of 2000 gal. of oil (roughly 16,000 lb.) circulating at the rate of 150 gal. per min. will dissipate the heat of 80 lb. of steel in the form of a shell, cooling this steel at the rate of 1100 deg. F. per min., and yet keep the oil at a temperature of 150 deg.

Fuel Oil Storage and Supply and Blast Piping

The general drawing Fig. 1 shows location of these items of equipment. The fuel oil was stored in and supplied from a 25,000-gal. cylindrical tank about 25 ft. in height, giving a maximum pressure at the burners of about 9 lb. per sq.in. and an average pressure of about 5 lb. Air was supplied by three No. 45 blowers at about 8-oz. pressure per sq.in. The same drawing shows location of the pyrometer system, which was furnished by the Wilson-Maeulen Co. and gave satisfactory results. Pyrometer wiring was placed in conduit 1 ft. below ground, rising directly alongside the furnace. Indicators and tapalogs were supplied to each row of furnaces.

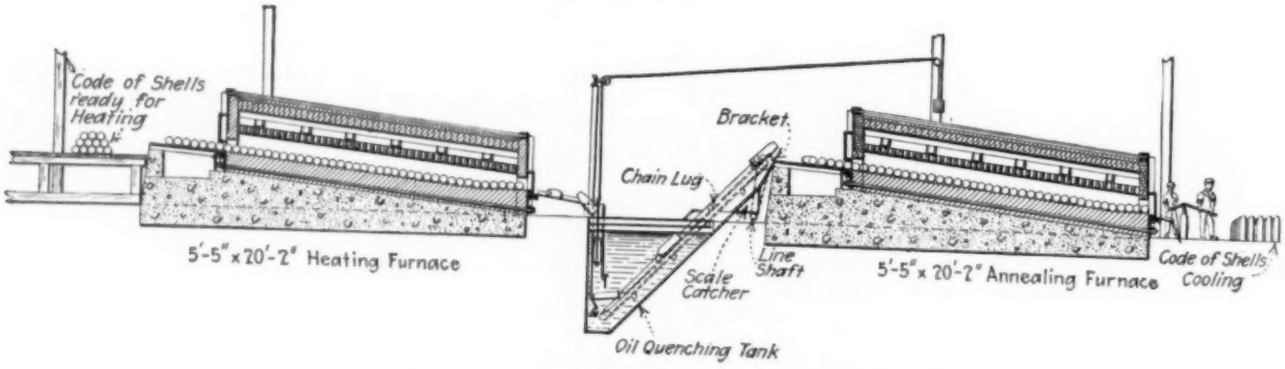


FIG. 3. GENERAL CROSS-SECTION OF HEAT-TREATING PLANT

Fuel Oil and Quenching Oil Consumption

Our fuel oil consumption was checked regularly and amounted to about 3.5 gal. per hr. per burner; 8 burners were used in each furnace, which gives a fuel consumption of 28 gal. of oil per furnace per hr., or per 60 shell. The consumption of quenching oil was due to its evaporation, plus leakage and the oil film adhering to shell carried out of the tank. This amounted to about 1 gal. of oil per 15 shell, a figure which well indicates the efficiency of our circulating and cooling system.

Heat-Treating Practice

After rough turning, nosing-in of forging and rough turning the nose end, the shells are sorted into code lots, and piled or stacked in test lots upon the platform in the rear of the heating furnaces. Respective test lot numbers are stamped on the shell, these lots consisting of 700 pieces selected according to formula. This formula depended upon chemical analysis; after allowing a maximum carbon range of 0.06 per cent,

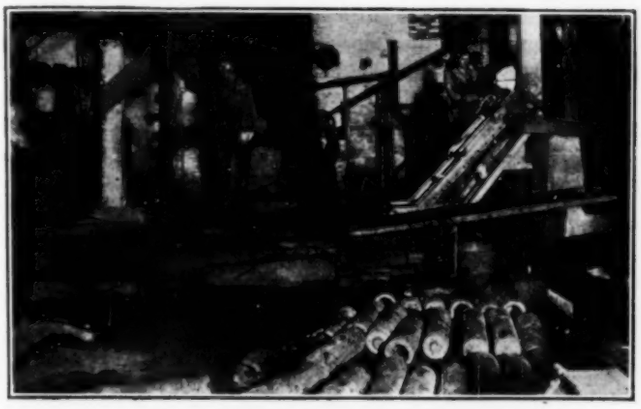


FIG. 4. OIL-QUENCHING TANK AND CONVEYOR

the maximum variation 3C + Mn must not be above 0.25.

The shell is then loaded on the rear platform of the heating furnace and rolled down its inclined bottom by gravity (Fig. 2), a furnace holding about 75. These are withdrawn at the discharge end at a rate of one every minute, thus giving a heating period of 1 hr. 15 min. to reach the required temperature of 1550 to 1575 deg. F. From this temperature they are automatically quenched in the tank described above and illustrated herewith, cooling to about 400 deg. F. before being deposited upon the rear platform of the drawing furnace. Quenched shells are immediately charged, reheated to the proper temperature and withdrawn. The annealing temperature is in the neighborhood of 1220 deg. F., depending upon the carbon and manganese analysis of the steel in that particular lot of shells. The time interval of the heating to this temperature is about the same as in the first furnace, namely, 1 hr. 15 min., although the shell was never withdrawn until a uniform heat was obtained.

Upon withdrawal the shell rolls into a chute which lands it in an upright position on the floor in front of the furnace, from where it is carried by tongs inserted in the open end of the nose to a cooling floor, where it is air-cooled in an upright position.

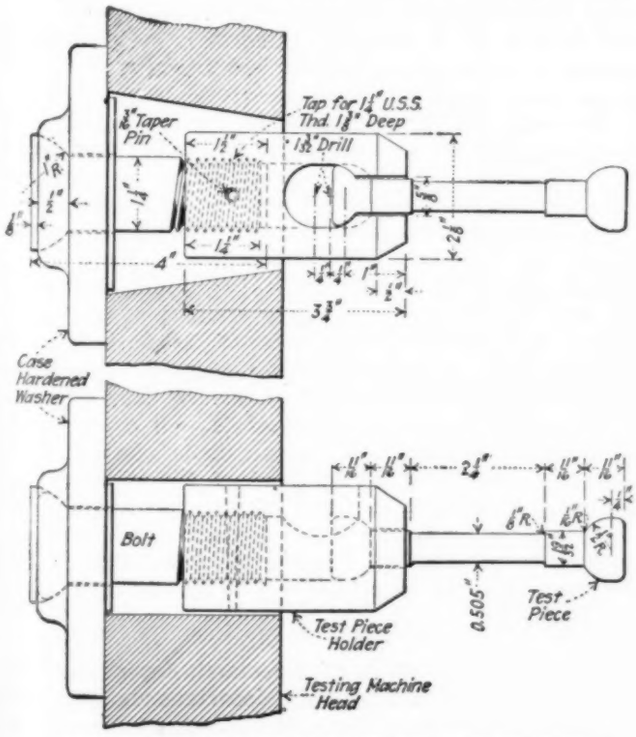


FIG. 5. DETAILS OF TEST PIECE AND HOLDER

When cool, two shells are taken at random for testing and the lot is released upon meeting the physical requirements of the specification for a 155-mm. high-explosive shell, each shell, however, being stamped with proper heat-treatment mark.

Test Specimen and Holder

To facilitate the machining of test pieces and in order to avoid threading the ends, we adopted a specimen having ends with spherical shoulders. This is illustrated in Fig. 5, together with details of a holder of my design, which is in fact and principle a double ball joint. The use of this device eliminated side stresses to an extreme minimum and assured automatic alignment with more consistent results than any other holder or type of specimen in general use. Over 50 per cent of our broken test pieces show full cups, and we attribute this fact to the holder in use and its resulting perfect distribution of the tensile stresses.

Conclusion

The plant above described has a record of 100 per cent efficiency in heat treating, not a single failure being recorded for the entire contract. The results of our practice are therefore of a most gratifying character, and I attribute our success not only to the personal efforts of the officials and operatives, but more especially to a logically planned and correctly laid out equipment. We, therefore, feel that it may be of some value and benefit to give our methods this publicity, thinking that possibly it may add some useful information to that already available to the man who has to plan and develop an efficient heat-treating department.

Pittsburgh, Pa.

By-Product Coke Oven Operations

Some interesting figures compiled by the War Department comparing the operation of by-product coke oven plants in 1917 with operations in 1918 have been made public in the course of the probe in War Department expenditures being made by a committee of the House of Representatives. The percentage of capacity realized in production in 1917 averaged 88. In 1918 the average was 86.9 per cent. Plants realizing 100 per cent production in 1917 were the Ensley and Tuscaloosa plants of the Semet-Solvay Co., the Fairfield plant of the Tennessee Coal, Iron & Railroad Co., the South Chicago plant of the Semet-Solvay Co., the Sparrow's Point plant of the Bethlehem Steel Co., the Duluth plant of the Minnesota Steel Co., the West Duluth plant of the Zenith Furnace Co., the St. Louis plant of the Laclede Gas Light Co., and the Steelton plant of the Bethlehem Steel Co. In 1918 no plant realized 100 per cent production. In 1918 the per cent of capacity lost on account of no coal was 5.1. In 1917 the capacity lost on account of no coal was 18.75 per cent. In 1918 the toluol per ton of coal averaged 0.31 gal. In 1917 the toluol per ton of coal was 0.27 gal. The amount of ammonium sulphate equivalent per ton of coal in 1918 was 18.07. In 1917 it was 18.95.

Industrial Research in Small Establishments*

By M. E. Leeds

In the past few years, and particularly during the war, research in connection with industry has had much consideration. Most of our large technical societies have devoted sessions to its discussion and have listened to admirable papers on the subject. I hope not to retraverse the ground thus covered. In this audience the vital importance of research to our technical industries would not need arguing even if it had not been amply argued. In these discussions research has been considered as something to be carried on in large well organized laboratories, and for that reason possible only for large companies, for associated companies managing a co-operative laboratory or for Government laboratories and the like. I believe that this way of thinking of research unnecessarily restricts it, and that differently conceived its usefulness to small as well as large establishments would become evident and might result in its large extension.

Research in a Small Business

The various activities covered by such titles as "Research," "Development" and "Technical Control" are those which should be assumed by a research department in a small business. In order to avoid a cumbersome name for such a department, I want to make a plea for a definition of technical research which some of you may think degrading. Doubtless you are accustomed to thinking of research as an adventure into the realms of the absolutely unknown. A department capable of research in this sense will be possible in a small business only when that business happens to have in it a real scientist. But every technical business (and what manufacturing business is not technical?) is continually confronted with the need of more information than is possessed by its regular staff in regard to processes, characteristics of materials, etc., and if it is to develop realizes that it must find new fields for its product and find new product to sell.

Suggested Definition of Industrial Research

The most advantageous solution of problems of this character cannot be left to people who are busied with the routine problems of sales and production. They can best be handled by a staff, even if a very small one, set aside for this purpose. I want to suggest that any department having such functions may be called a research department, and that industrial research may be defined for any given establishment as all that class of work which enlarges the technical horizon of the establishment beyond what is necessary for the routine production and test of its product.

You will note that this will make a sharp distinction between a research laboratory and a testing laboratory. I should not want to see a chemical laboratory, however large and elaborate its equipment or however highly trained its staff might be, called a research laboratory if its sole function happened to be routine analysis and check on the product. On the other hand, I should like to see any little room with even a very meager equipment and staff, perhaps only a single individual, called a research laboratory provided the functions of that individual and equipment were solely the improvement of processes, investigation of properties of materials new to the industry, development of new products, etc. And I should want to have it called a research department even if the research be chiefly carried on in libraries or other places for the purpose of bringing information, elsewhere well known, to an establishment to which that information happens to be new.

Large Capital Not Needed for Research Functions

This conception of research widely recognized might be the occasion for many small industries to start research departments, which these industries now regard as possible only for large capital. In this sense many small industries already have individuals with research functions who have other duties as well and do not clearly recognize their research functions. Under these circumstances both the research and the other work suffer, and as the business develops research does not find the best relation to the work as a whole.

Research, development and technical control merge into each other at many points, and in all but very large establishments can probably best be carried on by a group working under one head. Why attempt lines of demarcation?

Co-ordination of Research With Industry Needed

In order that research may find its fixed and recognized place in industry it is desirable that it be carefully planned and controlled, and that its results be carefully watched. So far as I know, these two conditions of the successful co-ordination of research with industry have not been discussed. Control in the sense of control of the research in the laboratory after it has been decided on has had discussion, and I do not refer to it, but to the determination of the subjects which shall be investigated in the research department and the decision as to when the research is completed, or, in case it is one that does not lead to satisfactory results, when it shall be abandoned.

For some five or six years this class of decisions in connection with our research department has been made by a committee of which the president of the company, the head of the research department, and representatives of the sales, engineering and production departments are members. This committee, called the research committee, meets once in two weeks, passes on all new subjects for the research department to handle, listens to reports on the progress of the work in hand and passes on recommendations in regard to the conclusion or discontinuance of work. In this way the work of the research department is well co-ordinated with the needs of the business as a whole. As a further factor in co-ordination the head of the research department is one of the board of directors and sits on the executive committee. The research committee has nothing to do with the internal administration of the department, which is left entirely to its own staff.

Costs Should Be Charged and Results Credited

Records of the results of a research department can best be kept by the accounting department. It is just as important to know the cost of research as of any other department, and, as in other cases, the usefulness of the record depends to a very large extent on its sub-

*Read before the Philadelphia meeting of the American Physical Society (Oct. 11, '19).

division. It is worth while to know what investigations contribute to business success and what ones do not.

Some years ago we worked out a plan of determining research cost and making credits to the department which has given us much valuable information. Each investigation undertaken has its cost record kept by the accounting department in the same way that a production order has. We of course do not ask our research men to register their time on a time clock or anything of that kind, but we do ask them to make a memorandum of the work on which they spend their time and turn in to the accounting department once a week a statement of the distribution of their time over the orders running in the department.

Method of Determining Research Costs and Making Credits

Similarly, expenses and costs of materials are kept, and when an investigation is closed its total cost is determined. If it happens to be one that has to do with manufacturing processes, such as test of new materials, etc., or development of new methods, it is either charged to general expense or to the expense of some particular product. If, however, it is a piece of work which results in the development of a new instrument or product for sale, it is treated in the same way that a new instrument developed and brought in by an

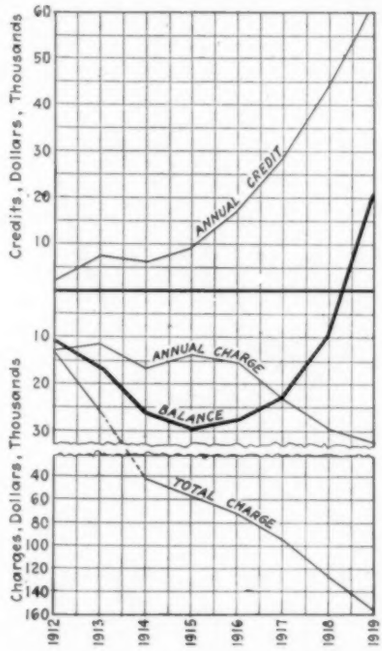


DIAGRAM SHOWING RELATION OF RESEARCH COSTS TO CREDITS

outsider would be. The research committee decides how much royalty can properly be charged to the cost of the instrument, and then as each instrument is made the royalty is added to its cost and is credited against its cost account in the research department.

Royalties Credited to Successful Developments Pay Cost of Department

In that way a continuous record of the usefulness of the research to the business is available. In cases of minor importance it is customary to discontinue credits when the cost has been covered. In cases where new products result they are allowed to run on indefinitely. Successful developments accumulate royalties that more than pay for the cost of their research and offset the costs of work that leads to nothing. The diagram shows the relation of annual and accumulated costs of research to the annual and accumulated credits since the department was given a distinct place. In a little over six years the total credits had equalled the total charges and the balance went to the credit side. On the books the account is closed out each year to profit and loss. It is carried forward as a memorandum account only. In the earlier years of the record the total volume of business done by the company was but a few hundred thousand dollars per year.

Plea for Distinct Department Having Its Proper Place as Do Other Departments

To summarize, I am making a plea for a conception and organization of research which will allow it to emerge as a distinct department in any growing technical business and take its proper place just as sales, production and accounting do. Any technical business ambitious to grow and render worthy service must in some way avail itself of research. Kenneth Mees and others have pointed out how industry in the past has developed around invention and research, although the distinctiveness of these functions was not clearly recognized, and in many cases they were not directly associated with the business which profited by them. Certainly an enterprise will have a more worthy and normal growth if its need for research is early and clearly recognized, and the research department will more easily find its proper relation to the business as a whole if it is established early and its place and functions are defined. After a business has assumed large proportions, and research functions are distributed in scattered manufacturing and engineering departments, it is difficult to gather them together and co-ordinate them.

This Conception of Research Not Violative of Good Usage

Let me remind those of you who may think this conception of research degrading that the present scientific limitation of the word is modern and confined to the exact sciences. The Century Dictionary gives its definitions in this order:

1. Diligent inquiry, examination or study
2. Laborious or continued search after facts or principles
3. Investigation

and quotes from Cowper

> He sucks intelligence in every clime
> And spreads the honey of his deep research
> At his return—a rich repast for me

so I think the definition which I propose does not violate good usage. Even if it did, would not the possibilities of development and usefulness to industry which this definition allows justify it in the same way that Bryce, in his American Commonwealth, writing of the third quarter of the last century, said that the application of the name "university" to many institutions which were no more than colleges or in some cases high schools was a favorable sign because it showed an aspiration, and that where the aspiration existed the reality would follow? We all know to what a large extent this forecast has come true.

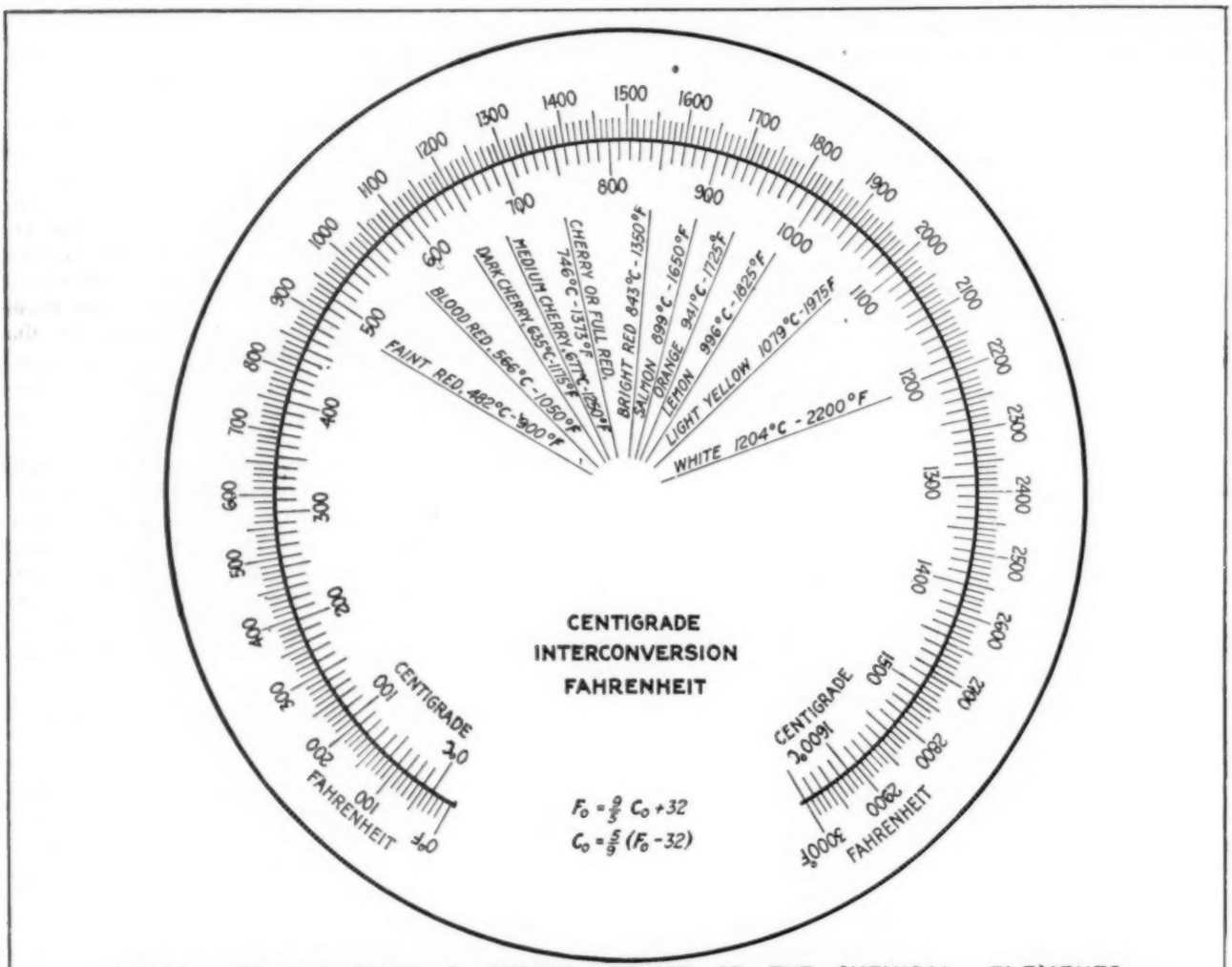
Leeds & Northrup Co.,
Philadelphia, Pa.

Convenient Chart in Chemical Works

There are any number of ways of assembling data for convenient use in chemical plants, one of which is shown below in the form of a chart with parallel temperature scales and an accompanying table. The Fansteel Products Co., Chicago, makes the information of easy access throughout its buildings by posting this chart on heavy cardboard in the laboratories, offices, furnace rooms and other locations where it is likely to be needed.

The radial lines in the top half of the scale giving the colors of metal opposite the corresponding temperature are especially valuable to the practical furnace operator in controlling the heats. At this plant, where a variety of furnaces are operating on the reduction of several of the rare metals, the table with atomic weights and melting points in both Centigrade and Fahrenheit is an added advantage.

Every one admits he knows the conversion factors for temperatures and the atomic weights of most of the elements, but with the chart at hand mental effort is saved and mistakes of memory eliminated.

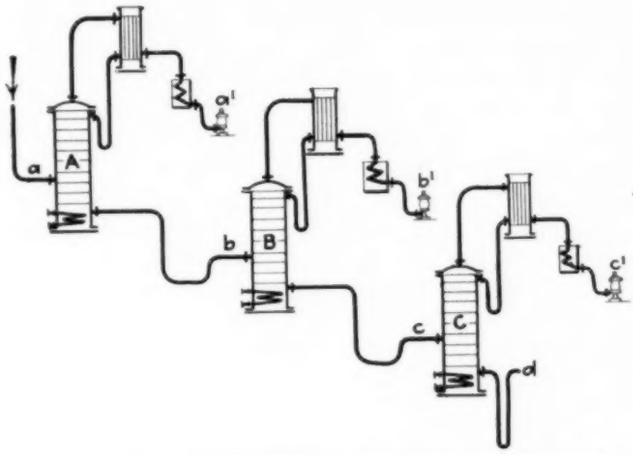


SYMBOL, MELTING POINT & ATOMIC WEIGHT OF THE CHEMICAL ELEMENTS

ELEMENT	SYMBOL	ATOMIC WEIGHT	MELTING POINT C°	MELTING POINT F°	ELEMENT	SYMBOL	ATOMIC WEIGHT	MELTING POINT C°	MELTING POINT F°	ELEMENT	SYMBOL	ATOMIC WEIGHT	MELTING POINT C°	MELTING POINT F°
ALUMINUM	Al	27.1	658.7	1217.7	HOLMIUM	Ho	163.5			RHODIUM	Rh	102.9	1950	3542
ANTIMONY	Sb	120.2	630.0	1166	HYDROGEN	H	1.008	-259	-434	RUBIDIUM	Rb	85.45	38	100
ARGON	A	39.88	-188	-306	INDIUM	In	114.8	155	311	RUTHENIUM	Ru	101.7	2450?	4442?
ARSENIC	As	74.96	850?	1562?	IODINE	I	126.92	113.5	236.3	SAMARIUM	Sa	150.4	1288	2348
BARIUM	Ba	137.37	850	1562	IRIDIUM	Ir	193.1	2350?	4262	SCANDIUM	Sc	44.1	?	
BISMUTH	Bi	208.0	271	520	IRON	Fe	55.84	1530	2786	SELENIUM	Se	79.2	217	423
BORON	B	11.0	2388?	4388?	KRYPTON	Kr	82.92	-169	-272	SILICON	Si	28.3	1420	2588
BROMINE	Br	79.92	-7.3	+ 18.9	LANTHANUM	La	139.0	810?	1490?	SILVER	Ag	107.88	960.5	1761
CADMIUM	Cd	112.40	320.9	609.6	LEAD	Pb	207.10	327.4	621.8	SODIUM	Na	23.00	97.5	207.5
CAESIUM	Cs	132.81	+26	79	LITHIUM	Li	6.94	186	367	STRONTIUM	Sr	87.63	>Ca<Ba?	
CALCIUM	Ca	40.07	810	1490	LUTECIUM	Lu	174.0			SULPHUR	S	32.07	112.8	235.0
CARBON	C	12.00	>3600	> 6500	MAGNESIUM	Mg	24.32	651	1204				119.2	246.6
CERIUM	Ce	140.25	640	1184	MANGANESE	Mn	54.93	1260	2300	TANTALUM	Ta	181.5	2850	5160
CHLORINE	Cl	35.46	101.5	-150.7	MERCURY	Hg	200.6	-38.9	-38	TELLURIUM	Te	127.5	452	846
CHROMIUM	Cr	52.0	1520	2768	MOLYBDENUM	Mo	96.0	2500?	4500?	TERBIUM	Tb	159.2		
COBALT	Co	58.97	1480	2696	NEODYMIUM	Nd	144.3	840?	1544?	THALLIUM	Tl	204.0	302	576
COLUMBIUM	Cb	93.5	1700 ?	3090?	NEON	Ne	20.2	-253?	-423?	THORIUM	Th	232.4	>1425	>2597
COPPER	Cu	63.57	1083.0	1981.5	NICKEL	Ni	58.68	1452	2646	THULIUM	Tm	168.5		
DYSPROSIUM	Dy	162.5			NITRON, RADIUM EMANATION	Nt	222.4			TIN	Sn	119.0	231.9	449.4
ERBIUM	Er	167.7			NITROGEN	N	14.01	-210	-346	TITANIUM	Ti	48.1	1800	3272
EUROPIUM	Eu	152.0			OSMIUM	Os	190.9	2700?	4900?	TUNGSTEN	W	184.0	3000	5430
FLUORINE	F	19.0	-223	-369	OXYGEN	O	16.00	-218	-360	URANIUM	U	238.5	< 1850	< 3362
GADOLINIUM	Gd	157.3			PALLADIUM	Pd	106.7	1549	2820	VANADIUM	V	51.0	1720	3128
GALLIUM	Ga	69.9	30	86	PHOSPHORUS	P	31.04	44	111.2	XENON	Xe	130.2	-140	-220
GERMANIUM	Ge	72.5	958	1756	PLATINUM	Pt	195.2	1755	3191	YTTEBBIUM	Yb	172	?	
GLUCINIUM	Gl	9.1	1350?	2462?	POTASSIUM	K	39.10	62.3	144	YTTRIUM	Yt	89.0	1490	2714
GOLD	Au	197.2	1063.0	1945	PRASEODYMIUM	Pr	140.6	940?	1724?	ZINC	Zn	65.37	419.4	786.9
HELIUM	He	3.99	<-271	<-456	RADIUM	Ra	226.4	700	1292	ZIRCONIUM	Zr	90.6	1700?	3090?

Synopsis of Recent Chemical and Metallurgical Literature

Continuous Rectification of Crude Benzol.—Mr. A. BARIL gives, in the September, 1919, issue of *Chimie et Industrie**, an interesting description of the Gennevilliers gas works plant for the continuous rectification of crude benzol. The apparatus employed consists of three columns, each provided with its own heating arrangement. The crude benzol enters column *A* at *a*. By heating, the first distillate (CS_2, etc.)



SCHEMATIC ARRANGEMENT FOR THE CONTINUOUS RECTIFICATION OF CRUDE BENZOL

is separated at *a'*. Here testing apparatus is provided for the purpose of controlling the operation of the column. The partially rectified crude remaining in *A* enters column *B* at *b*. The heating of this column is so regulated that the pure benzene fraction is collected at *b'*. The product remaining in *B* passes through *c* to the column *C*, where, by a similar procedure, pure toluene is obtained at *c'*; the residual product, solvent naphtha, being drawn off through *d* to suitable storage tanks.

Allotropic Nitrogen.—The October number of the *Catalyst*[1] contains the following discussion on allotropic nitrogen by Dr. HENRY LEFFMANN:

"Until the discovery of the so-called 'noble' gases—the argon group—nitrogen was generally considered by chemists as the most indifferent of the elements as far as properties in the free state are concerned. In contrast with this is the fact that it occurs in nature in many combinations with a variety of elements, and while direct combination is difficult to bring about, many artificial compounds can be obtained by indirect means, among which is the effect of nascent state. Moreover, many of the compounds of nitrogen, however obtained, are not easily decomposed; even the associations with hydrogen and carbon, which from theoretic consideration would seem to be loose unions, are quite stable.

"Many years ago, Professor H. E. Armstrong expressed the view that an allotropic form of nitrogen characterized by much higher affinity than the common form would be obtained, and it seems that such a form has been discovered. Allotropism is an interesting phenomenon and several striking examples have long been known. Two of the most interesting are seen in phosphorus and oxygen. It is curious that the active and inactive forms of these elements are reversed as to frequency of occurrence. Phosphorus, as obtained in the free state by standard processes, is always the active form, oxygen under similar conditions always the inactive form, with, it is true, often minute amounts of the active modification.

"In 1911 Strutt published in the *Proceedings of the Royal Society* (1911, vol. 85, p. 219), an account of experiments in which nitrogen was subjected to the action of electrical discharges by which new qualities were acquired. The methods and results given in this paper were in outline as follows: Pure nitrogen from any source subjected to jar discharge undergoes a change by which it acquires a short phosphorescence and much increased combining power, combining directly with phosphorus, also with sodium and mercury, at a gentle heat, forming, in the case of last named, an explosive compound. The action on phosphorus is accompanied by the formation of much red phosphorus. (In this is to be noted some analogy to the action of iodine on phosphorus, in which case red phosphorus is also formed.) The modified nitrogen attacks nitric oxide (NO), forming, strangely, nitrogen dioxide (NO_2).

"It attacks acetylene and many hydrocarbon haloids, setting free the halogen and forming cyanogen.

"Strutt's inferences were at once challenged by several investigators, especially in Germany, and for some years a running fire of criticism and counter-criticism has been going on. On Feb. 21, 1918, Strutt delivered before the Chemical Society a lecture on the subject in which he repeated some of his experiments and gave the results of later investigations, especially in the light of the objections that had been made. Among the most important of these objections is that the nitrogen he used was not pure, and that the effects observed were due to the impurities. Oxygen was claimed as the principal impurity. Strutt's lecture appears in the publication of the Society (*J. Chem. Soc.*, 1918, vol. 113, p. 200). He makes the following statements: Pure nitrogen does not give the modification, but traces of many other substances suffice to activate it. Oxygen is one of these, but hydrogen sulphide, ethylene and methane are also active. It seems, then, that a sort of catalysis is essential.

One of the most marked indications of the change in the nitrogen is that it acquires a peculiar glow under the influence of the electric discharge, which persists for a brief period after the discharge ceases. Here there seems to be some analogy to phosphorus, which is a member of the nitrogen group. The subject is interesting, and in the increase of work in pure science, which must soon begin under the conditions of peace, further interesting data concerning it will probably be obtained. Strutt obtained nitrogen mostly from liquid air.

"It is worth noting that Briner and Baerfuss (*J. Chim. Phys.*, 1919, vol. 17, p. 71), in studying the production of ammonia under the influence of arc discharges, did not observe any of the effects on the nitrogen such as Strutt records."

*La rectification continue des benzols. A. Baril. *Chimie et Industrie*, vol. 2, No. 9, September, 1919, pp. 1013-1016.

[1]The *Catalyst* (official bulletin of the Philadelphia and Delaware Sections of the American Chemical Society), vol. 4, No. 8, p. 6; October, 1919.

Recent Chemical and Metallurgical Patents

American Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Process of Recovering Quicksilver From Its Ores.—HENRY W. GOULD of San Francisco, Calif., improves the process of condensing quicksilver vapors which are liberated from roasting ores. The vapors from the furnace are passed through a dust chamber and thence into an inclined conduit made of terra cotta or tile pipe, which acts as a condenser, and the condensed quicksilver is collected from a receiver at the lower end of the conduit. In order to assist in the condensation and, principally, to prevent the precipitation of soot, dust and ash, air under pressure is introduced into this inclined conduit through a nozzle and in the direction of the flow of gases through the conduit. This prevents to a large extent the precipitation of soot, and the condensed quicksilver will readily coalesce. The conduit is of sufficient length to insure the condensation of a large portion of the quicksilver. Brick condensing chambers of the usual form are also provided. (1,315,663, Sept. 9, 1919.)

Process for the Extraction of Sulphur From Metal Sulphides.—MAX HELBIG of Fredriksstad, Norway, obtains sulphur from pyrites by mixing pyrites, apatite, coke and quartz in proportions calculated to correspond to the equation

$$4FeS_2 + Ca_3P_2O_8 + 5C + 3SiO_2 = 8S + 2Fe_2P + 5CO + 3CaSiO_3.$$

An enclosed electric furnace to which is connected a condenser is used to carry out the process. (1,315,496, Sept. 9, 1919.)

Method of Briquetting Finely Pulverized Iron Ore.—J. R. H. A. LAMMERHIRT of Hoerde, Germany, has invented a process whereby finely pulverized ferroso-ferric oxide of iron or magnetic iron ore concentrates may be formed into a briquet. The method consists of adding iron in the form of shavings and finely pulverized ferric oxides or oxyhydrates in a small proportion to the oxide or ore to be briquetted. The process is most efficient if the iron oxide be slightly moist. (1,315,315, Sept. 9, 1919.)

Shellac-Naphthalene Plastic Composition.—In the manufacture of shellac-impregnated paper and cloth for electrical insulating purposes, it has been customary either to mix the shellac with oil, which is a difficult matter, or to dissolve the shellac in wood alcohol. In the latter case, it is found that the presence of wood alcohol, which can be completely removed from the shellac only with great difficulty, lowers the dielectric strength of the product. JAMES P. A. MCCOY of Wilkinsburg, Pa., has found that a mixture of shellac and naphthalene is fluid when heated and forms an excellent impregnating and binding material. The resulting products are flexible, unless heated sufficiently to volatilize the napthalene. If permanently flexible products are desired, the naphthalene should be replaced by naphthols or other naphthalene derivatives (except chloronaphthalene). (1,317,204; assigned to Westinghouse Electric & Mfg. Co.; Sept. 30, 1919.)

Recovery of Carbon Bisulphide in Benzene Distillation.—The percentage composition of that fraction of light oil known as "90 per cent benzol" is about 70 per cent benzene, 24 per cent toluene, including a little xylene, and 4 to 6 per cent carbon bisulphide and light hydrocarbons. Attempts to recover the carbon bisulphide by fractional distillation have been unsucessful, since the boiling points of pentane (the principal light hydrocarbon in this fraction) and CS_2 are so close together, i.e., 37 and 46 deg. C. respectively. By treating this fraction with a halogen in the presence of a suitable catalyst, HERBERT H. DOW obtains a mixture of CS_2 and a halogen derivative of pentane having a boiling point sufficiently above that of CS_2 to make practicable the process of separation by fractional distillation. For example, when chlorine is used pentyl chloride ($C_5H_{11}Cl$; b.p. 160 deg. C.) is formed. (1,317,359; assigned to the Dow Chemical Co.; Sept. 30, 1919.)

Purification of Nitrous Oxide.—Ammonium nitrate is heated to 250 deg. C. in an aluminum retort. The gases evolved pass through a condenser and are then purified by scrubbing with acid potassium permanganate solution, 10 per cent sodium hydroxide and 20 per cent sulphuric acid. All impurities are eliminated, with the possible exception of a trace of nitric oxide, which disappears when the gas is allowed to stand for a period of 48 hr. in an iron or other metallic container. (1,315,354; ANDREW R. WARNER, assignor to Lakeside Hospital, Cleveland, Ohio; Sept. 9, 1919.)

British Patents

Complete specifications of any British patents may be obtained by remitting 25c. each to the Superintendent British Patent office, Southampton Buildings, Chancery Lane, London, England.

Picric Acid.—Picric acid is obtained by nitrating with nitric acid and concentrated sulphuric acid, the dinitrophenol produced by treating 1-chlor-2.4-dinitrobenzene with caustic alkali. (British Patent 9962—1915. L. G. BADIER and L. B. HOLLIDAY, both in Huddersfield; May 14, 1919.)

Calcium Nitrate.—In the production of calcium nitrate by the reaction of calcium chloride on sodium nitrate in solution, the calcium chloride is employed in excess, for instance an excess of 10-20 per cent, and the mixed solution is evaporated, for instance until its boiling point is 130-140 deg. C., and then cooled or allowed to cool, for instance to 60 deg. C., the sodium chloride which separates during these operations being removed; then the solution is diluted, for instance until its boiling point would be about 128 deg. C., and is then further cooled, whereupon calcium nitrate crystallizes out and is washed with water or calcium nitrate solution, and, if desired, may be recrystallized. In recrystallizing, a solution of a boiling point of about 121 deg. C. may be employed, and the mother liquor may be used for washing the crystals first obtained or for diluting the original solution prior to the first crystallization. (British Patent 10595—1915. S. SMITH and AMMONIA SODA CO., Northwich; May 14, 1919.)

Nitrogen Oxides.—For obtaining nitrogen oxides by catalytic oxidation of ammonia, the catalysts employed consist of a mixture of iron oxide, oxide of metal electronegative to iron and reduced but not fused

under the working conditions, such as copper and oxide of an alkaline-earth metal. Hydroxides, carbonates, or other salts may be employed instead of oxides if they are converted into oxides under the working conditions and do not introduce contact poisons. In the examples a mixture of ferric and copper nitrate is precipitated by sodium hydrate or carbonate, and slaked lime is mixed with the washed precipitate, the mixture being molded, dried, and calcined; and a mixture of ferric, copper, and calcium nitrates is precipitated in a similar manner, and the precipitate is similarly treated. (British Patent 10781—1915. E. B. MAXTED and G. R. RIDSDALE, both in Walsall, Staffordshire; May 14, 1919.)

Picric Acid.—In the production of picric acid by sulphonating phenol and nitrating the sulphonation products, the temperature of nitration is not allowed to exceed 118 deg. C., and is maintained for approximately 8 hours. The temperature is preferably maintained at 110-118 deg. C., either by external regulation of temperature or by commencing the reaction at 80-95 deg. C. (British Patent 14367—1915. N. H. GRAESSER and A. W. TITHERLEY, Ruabon, Denbighshire; March 14, 1919.)

Acetone, Acetates and Pyruvates.—Method of making acetates and pyruvates by the action of the mold Amylomyces rouxii on a starchy or sugary mash in the presence of an alkaline-earth carbonate. The pyruvates can be converted into acetates by oxidation. The salts can be converted into free acetic acid and then into acetone; or acetone may be obtained directly by the destructive distillation of the salts, air or oxygen being admitted, if desired, to the apparatus in which the distillation is effected. (British Patent 14607—1915. A. FERNBACH, Paris, France, and E. H. STRANGE, London, England; May 14, 1919.)

Explosives.—Methods of preparing explosives which consist in gelatinizing nitrocellulose-nitroglycerine explosives containing more than 50 per cent of nitroglycerine at ordinary temperatures by the addition of 0.1 to 1.0 per cent, calculated on the nitroglycerine content, of aromatic nitro-compounds such as mono-, bi- and tri-nitrotoluenes, mononitronaphthalene, dinitrobenzine, nitroxylenes, and mixtures of these, also "liquid trinitrotoluene." One example contains nitroglycerine 89.8 per cent, soluble nitrocellulose 8.7 per cent, liquid trinitrotoluene 0.9 per cent, and calcium carbonate 0.6 per cent. (British Patent 14656—1915. W. RINTOUL, D. CROSS, and NOBEL'S E PLOSIVES Co., Ardeer factory, Stevenston, Ayrshire; May 14, 1919.)

Explosives.—Methods of preparing explosives which consist in gelatinizing nitrocellulose-nitroglycerine explosives at ordinary temperatures by the addition of 0.1 to 1.0 per cent, calculated on the nitroglycerine content, of substances of the following classes: Urethanes or esters or carbaminic acid, anilides, substituted ureas, condensation products of glycol and other polyhydric alcohols with aldehydes, homologues of oxanilic ester, and the well known solvents of nitrocellulose such as acetone, acetic ester, and amyl acetate. One example contains nitroglycerine 91.6 per cent, soluble nitrocellulose 7.5 per cent, formanilide 0.2 per cent, formotoluidide 0.1 per cent, and calcium carbonate 0.6 per cent. (British Patent 14655—1915. W. RINTOUL, D. CROSS, and NOBEL'S EXPLOSIVES Co., Ardeer factory, Stevenston, Ayrshire; May 14, 1919.)

Personal

Mr. H. R. BEARD, formerly chemist with the Nitrate Division, Ordnance Department, has been appointed an instructor on the staff of the University of Wisconsin, Madison, Wis.

Lieut. J. H. BECQUE, who has been stationed at the U. S. Chemical Plant, Saltville, Virginia, has received his honorable discharge from the Army, and has accepted a fellowship at the Mellon Institute, Pittsburgh, Pa.

Mr. M. J. BLEW has been appointed assistant professor in analytical chemistry at the University of Louisville, Louisville, Ky.

Mr. JOHN G. BRICKEY has been recently employed as research chemist by the Miner Laboratories, Chicago, Ill.

Dr. C. B. CLEVENGER, recently with the U. S. Soil Survey, has been appointed on the staff of the University of Wisconsin, Madison, Wis.

Mr. FERDINAND P. EGEBERG, a distinguished Norwegian engineer, is at Salt Lake City, on his way to Arizona, where he will study methods of flotation.

Mr. J. B. FROST, formerly with the Semet-Solvay Co., has accepted a position on the staff of the Burgess Laboratories, Madison, Wis.

Mr. SAMUEL HERSCH, formerly metallurgist at the Rear Axle plant of the Maxwell Motor Co., Inc., Detroit, is now connected with the Forest City Machine & Forge Co., of Cleveland, in the same capacity.

Mr. ROBERT M. KEENEY has been retained by the Westinghouse Electric & Manufacturing Co. in a consulting capacity in connection with the development of ferro-alloys now being undertaken by the Westinghouse company.

Dr. S. C. LIND, formerly of the University of Michigan, has succeeded Dr. R. B. Moore as chief of the Colorado Station of the Bureau of Mines. Dr. MOORE has been appointed chief chemist and chief of the Division of Mineral Technology of the Bureau and will be located in Washington, D. C.

Mr. V. W. MELOCHE has accepted an appointment on the staff of the University of Wisconsin, Madison, Wis.

Mr. G. H. MONTILLON has been appointed an instructor in chemical engineering at the University of Wisconsin, Madison, Wis.

Mr. F. G. MOSES has resigned from the staff of the Salt Lake City Station of the Bureau of Mines and is now with The Barrett Co., with headquarters at Salt Lake City, Utah.

Dr. HUBERT L. OLIN, well known to the industry for his work in the chemistry and engineering of fuels, has been appointed chief of the department of industrial chemistry and chemical engineering, Iowa University, Iowa City, Ia.

Mr. J. BENJAMIN PARKER, metallurgist, Salt Lake City, Utah, has accepted a position as flotation engineer with the Interstate-Callahan Mining Co., Wallace, Idaho.

Mr. ROSS PARMELEE has accepted a position with the Redmanol Chemical Products Co., and will be employed chiefly on research work in Redmanol. Previous to entering the Chemical Warfare Service Mr. Parmelee was plant manager for the Armour Soap Works, Chicago, Ill.

Mr. FRANK M. SMITH, for many years, in fact since its construction, in charge of the East Helena smelter of the American Smelting & Refining Co., has become assistant director of the Bunker Hill & Sullivan Co., with offices in Spokane. Mr. Smith's wide knowledge of Western ore producers will be utilized by the new company in a vigorous cultivation of the custom smelting business.

Mr. E. GYBBON SPILSBURY is on his way to Brazil to study the question of establishing steel works in that country, and expects to be absent three and one-half months.

Mr. E. P. STENGER has resigned from his position as metallurgist for the Sheldon Spring & Axle Co. to accept a position on the staff of Thompson & Black, financial accountants and engineers, Detroit, Michigan.

Mr. JOHN E. VALENTINE has accepted a position as chemist with the Synthetical Laboratories of Chicago, Ill. Mr. Valentine was previously employed in the Chemical Warfare Service, at Edgewood Arsenal.

Current Market Reports

The Non-Ferrous Metal Market

New York, December 12, 1919.

For the last week the copper market has been fairly steady, today's price being 18¾c. for spot. Fortunately, so far as supply is concerned, the curtailment of production because of fuel shortage is offset by exceptionally heavy stocks. With favorable financial conditions the export business would be heavy, as Europe stands in great need of copper. The demand for lead is strengthening as the offerings grow lighter. The market is rising, with brisk business at 7¼c. for spot. Indications are that Great Britain will be a steady buyer of zinc. The New York price was 8.70c. for spot. Other metals are quoted as follows:

	Cents per Lb.
Aluminum, 98 and 99 per cent	32.00—33.00
Antimony	9.62½
Copper, electrolytic	18.75
Lead, New York, spot	7.25
Lead, E. St. Louis, spot	6.90
Tin, Straits, spot	52.50
Zinc, New York, spot	8.70
Zinc, E. St. Louis, spot	8.37½
Copper sheets, hot-rolled	28.50
Copper bottoms	37.00
Copper rods	25.75
Copper wire	21.50
High brass wire and sheets	24.25
High brass rods	27.00
Low brass wire and sheets	26.25
Low brass rods	27.00
Brazed brass tubing	30.50
Brazed bronze tubing	40.75
Seamless copper tubing	32.00
Seamless bronze tubing	34.50
Seamless brass tubing	30.50

OTHER METALS

Bismuth, wholesale	lb.	$3.25—.....
Cadmium	lb.	2.50— $3.00
Cobalt	lb.	1.80—.....
Magnesium	oz.	.12½—.....
Nickel (ordinary)	lb.	.42—.....
Iridium	oz.	250.00—300.00
Palladium	oz.	150.00—.....
Platinum	oz.	150.00—.....
Silver	oz.	1.32½—.....

SCRAP METALS

	Buying at Cents per Lb.
Aluminum, cast	22½—23½
Aluminum, sheet	21½—26
Copper, heavy machinery comp	14½—14½
Copper, heavy and wire	13½—13½
Copper, light and heavy bottoms	12½—12½
Brass, heavy	7½— 8
Brass, light	5½— 6½
Lead, tea	4½— 4½
Lead, heavy	5½— 5½
Zinc	4½— 4½

The Iron and Steel Market

While the union bituminous coal miners began straggling back to work on Thursday, Dec. 11, following the Indianapolis settlement, it is probable that the iron and steel industry will feel the pinch of coal and coke shortage with increasing severity for a week or two after that date. A few steel mills and quite a number of finishing departments had closed from lack of coal at the time of the coal wage settlement, but quite a number of others are likely to be forced to close through their stocks being exhausted. The coal distribution regulations do not contemplate the distribution of more coal than enough to support a 50 per cent operation of by-product coke ovens and of steel mills, and there is no assurance of even such a quantity being actually furnished. A 50 per cent restriction in the production of beehive coke only began as the wage settlement was made, a 25 per cent restriction having been in more or less force for a few days previous, and coke from beehive ovens is usually in transit from one to two weeks, so that with the removal of the coking restrictions entirely problematical the blast-furnaces may have a coke shortage until the end of December, and possibly even longer.

SCARCITY OF STEEL

Appearances of steel being scarce have multiplied, but the coal strike itself can hardly be regarded as a cause of steel being scarce, since such observation as can be made rather suggests that the shortage of coal affects the consumption of steel more than its production. Many manufacturing consumers of steel have been closed by the coal shortage or the coal-consuming regulations.

Cases of buyers being in dire need of steel are impressive by reason of the severity of the condition rather than by reason of the tonnages required. Steel is much scarcer among jobbers than among manufacturing consumers, and a rough estimate is that normally only about 10 per cent of the steel produced passes through the hands of jobbers. In some quarters claims are made that mills have been favoring manufacturing consumers to the disadvantage of jobbers.

Fancy prices are being bid for steel, but only for a relatively small proportion of the various descriptions of finished steel turned out by the mills. There is much mention of sales of steel at prices above the March 21 schedule, but it seems certain that in all cases in which any considerable advance has been paid over March 21 prices, say an advance or premium of more than $5 a ton, the delivery involved is prompt and the tonnage relatively small.

STEEL CORPORATION ADHERES TO SCHEDULE PRICES

The United States Steel Corporation adheres very firmly to its doctrine that steel should not be allowed to advance in price above the March 21 schedule, and it carries its theory into practice, seeing that its unfilled tonnage at the end of November is reported at 7,128,330 tons. This indicates an increase of 655,662 tons during the month, and as the shipments were not far from 800,000 tons the corporation is seen to have sold nearly 1,500,000 tons of its products in the month, in no case charging more than the March 21 price. Nor is the Steel Corporation hopelessly oversold, as some producers predicted recently would be the case if it continued to sell at the old prices, since on a conservative estimate of its prospective output, with gains bringing the output in March up to the pre-strike rate, about 85 per cent of rated capacity, the shipments by the middle of June would be approximately equal to the unfilled obligations now reported.

Several of the large independents are committed to the same price policy as the Steel Corporation, while many of the small independents are seeking advanced prices. As they can furnish little tonnage against fresh sales before about April 1, they are in some instances refraining from selling at all.

Foundry pig iron has advanced in some markets in the week, valley and Philadelphia quotations being up $2 a ton, but bessemer and basic are unchanged. Quotations on foundry iron now are: Delivered Philadelphia, $40.10; at furnace, Buffalo, $39; Cleveland, $33; Chicago, $33; Birmingham, $34. The valley market stands at $35 to $38 for foundry, depending on delivery, with basic at $33 to $34 and bessemer at $35.

The Chemical Market

New York, December 12, 1919.

The demand for *heavy chemicals* remains strong, but trading is light owing to small stocks. Many firms have contracted three or four months into next year, but no further because of the unsettled conditions. The coal shortage which has slackened production will be felt in the market in a few months by buyers of these chemicals. *Coal-tar products* have advanced in some lines, with a large export demand that is being turned aside in favor of the domestic market. *Vegetable oils* have been dull, the buyers and sellers each looking at the market from a different angle. *Naval stores* have been firm, with a drop in some items in sympathy with the Southern market prices.

The *crude rubber* market has been inactive, except for a few small lot exchanges. *Flotation oils* are firm, with a

continued brisk inquiry. *Ammonium sulphate* went up and is now quoted at 1¾-2¼c. per lb.; there is a scarcity of raw material and the demand at present exceeds the quantity on hand.

The demand on *sodium bichromate* is excessive, and there is very little of it on hand even at 36-45c. per lb.

Formaldehyde and *caustic soda* have moved to the front both in demand and price, formaldehyde being listed at 32-35c. per lb., caustic at $3.80-3.85 per cwt. Both can be obtained only in small lots. *Glauber's salts* have been active at $1.50-2.25 per cwt. *Borax* at present is in large demand, increased from 8-8½c. per lb.

Benzol jumped from 25-29c. per gal. to 27-31c., and *toluol* rose from 30c. per gal. to 32c., with large demand for both. *Dimethylaniline* is quoted at 80-85c. per lb., while *aniline oil* can be had in carlots at 32c. per lb., with Japan a heavy buyer. *Alpha naphthol* and *paratoluidine* have been sold out for the first half of next year, with Japan a heavy buyer.

Denatured alcohol jumped to 68-70c. per gal. and no quotations on this item will be given after the first of the year. The demand has been both foreign and domestic and it is difficult to obtain this material, as all available will be used to fill contracts.

Paraffine waxes: Crude match wax (white) 105-110 m.p., is off the market, refined 118-120 m.p. jumped 9c. per lb. against 8½c. of last report, and refined 128-130 went up a cent to 10½c. per lb. This market has been active in exporting to Europe, Japan and South America.

Rosin B-D dropped to a low mark of $17-17.50 for 280 lb., against $17.30 of previous quotations, and *rosin E-1* sank to $17.55-18.25 per 280 lb., from $18.35-18.95 of last week. *Spirits of turpentine* took a jump from $16-17 per 280 lb. to $17-17.50, while *wood turpentine*, steam distilled, went to $1.63 per gal., compared with $1.50 of former report.

Ferro-Alloys

There have been no new developments recently, market prices in general continuing to rise and demand remaining about the same. Deliveries are a hazard, due to the coal shortage, and some plants have already cut down on their output. Despite these adverse conditions, however, the market continues to step along at its usual pace.

The uncertainty as to what tariff regulations will be imposed on *tungsten* has killed this market. *Scheelite* continues at $10-15 per unit, and there has been no change in *wolframite*, still quoted at $7-8 per unit.

Ferromanganese, 78-80 per cent Mn, has been active, with heavy demand and plentiful supply, at the following quotations: English at $110, domestic $120 per gross ton. The difficulty of obtaining freightage on manganese ore is holding up this item, which has been in large demand for furnace purposes, at 60-70c. per unit, 45 per cent and over, against 55c., the low market of last week. *Chrome ore*, 48 per cent and over, has jumped from 68c. to 70c. per unit. It is the opinion of some that a new price list will be effective about the first of the year. *Spiegeleisen* is quoted at $38 spot, $40 futures, f.o.b. furnace, with demand slightly increasing.

Government prices prevail on *coke*, with foundry nominally quoted at $7-8 per net ton, compared with last week's quotation of $5-6. *Furnace coke* has also gone up to $6-7, against $4-5 of the previous report. Exporting in this item has fallen off and all available material is being husbanded for domestic use in place of coal wherever possible. A serious shortage of *blanc fixe pulp* is accountable for the rise from $30-40 to $40-60 per ton, which is the present quotation. *Barytes white floated* remains firm at $30-40 per ton, with a large domestic demand which is being filled immediately, the surplus being exported.

An unprecedented demand on *feldspar* has left this item in the position of being quoted nominally at $13.50-18 per ton, which is the limit set by the Government. It is practically impossible to obtain any of this material, as the supply, which is greater now than it ever has been before, is going to fill up back orders. There has been no change in the general conditions of *talc*, domestic being quoted at $55-70 per ton, while foreign grades are listed at $16-60 per ton. *Soapstone* remains firm at $15-25 per ton.

Chicago, December 12, 1919.

Of outstanding interest in all lines of industry and commerce at the present moment, at least in the Middle West, is the effect of the existing fuel shortage. The chemical industry, as far as production is concerned, is touched to a relatively slight degree. Fuel administrators have ruled that where interruption of a continuous process would result in damage to plant or goods in process, no shut-down is necessary. Chemical processes which generate their own heat are likewise permitted to run, and only those which fall out of these two classes are required to conform to the three-days-a-week ruling.

This is also true in the metallurgical field, so that refiners and smelters are affected only so far as their receipts of ores are cut by the reduction of working time at the mines. Distribution is being affected to a certain extent, many users of chemical products being forced to suspend or operate on part time. The great fertilizer plants in the Chicago district are entirely shut down, but, as no deliveries are being made at this season of the year, the effect of this is almost nil. There is apparently no possibility of the cessation of production lasting long enough to cause any shortage next year.

Heavy Chemicals:—All prices are holding firm, with demand normal. A sudden unexplained shortage has developed in sodium bichromate, which, following its fluctuation between 13c. and 15c. in the last five months, has suddenly shot up to where 32c. would probably be a fair quotation today. Some offerings have been made at 40c., but none has changed hands at that figure. Ammonium chloride (white salammoniac) is also very scarce and has increased from 13c. a month ago to from 15c. to 16c.

Solid caustic soda is being sold heavily on export orders and the price is now up to about $4.00 cwt. f.o.b. works. The granulated is bringing about the same figure. Aside from the above mentioned items, the heavy chemical list shows no changes from quotations of recent date.

Coal-Tar Products: — Although no changes in quoted prices are seen, a decided stiffening of the market can be felt, due to scarcity of crudes. Spot stocks are very low and producers report output sold, in some cases, ninety days ahead. Continued difficulties with coal supply may lead to serious shortage. As previously noted, current prices are: On benzol, 25c.; toluol, 26c.; aniline oil, 32c. to 33c.; aniline salts, 36c.; salicylic acid, 45c.; benzoic acid, 95c.

Vegetable Oils:—Uncertain demand produced a spotty market in vegetable oils here recently. Cotton oil is firm, with crude quoted at 1c. advance, at 18c., and prime summer yellow in barrels at 25c. Demand seems to be slightly in excess of supply. Corn oil is fairly active, still being quoted at 18c. in sellers' tanks. Linseed took a big jump and is over $2 in less than 5-bbl. lots, $2.09 being asked. In larger quantities the price is around $2.04.

Cocoanut oil fluctuates between 17½c. and 18½c. for miller grade, with the general trend being toward the higher price, but with demand a little bit weak. Soya bean oil also showed strength, as sales were made at 17½c. in barrels, f.o.b. Chicago, with Pacific coast quotations ruling at 16½c. in sellers' tanks. The high price of silver in exchange with the Far Eastern countries will tend to strengthen greatly both copra and soya oils.

Flotation Oils—Naval Stores:—The upward trend of pine products, which was interrupted early in the fall, has, under pressure of export sales and exhaustion of stocks of small dealers, resumed its course, as had been anticipated. Turpentine heads the list with a quotation of from $1.95 to $1.98, and not much is available even at such figures. Pine tar oil is also higher, .933 pure steam distilled now bringing $1.60 to $1.65. Some industries requiring destructively distilled, and that commodity being so short as to be practically off the market, the usual differential between it and the pure has been wiped out, and it is now also quoted at $1.60 to $1.65. Rosin has held quiet since the last quotation, F grade still being obtainable at $19 and W. W. at $24.50.

Note: Owing to an error in proofreading, the price list printed in our last issue was dated Nov. 30 instead of Dec. 6.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.		$0.60 –$0.65
Acetone	lb.	$0.20 –	.21 –
Acid, acetic, 28 per cent.	cwt.	2.50 –$2.75	3.00 – 3.25
Acetic, 56 per cent.	cwt.	5.00 – 5.50	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.50–13.50	13.50–15.50
Boric, crystals	lb.	.13 – .13½	.13½– .14½
Boric, powder	lb.	.13 – .13½	.13½– .14½
Hydrochloric, (muriatic) tech. 20 deg.	cwt.	1.50 – 1.75	2.00 – 2.50
Hydrofluoric, 52 deg.	lb.	.12 –	.14 –
Lactic, 44 per cent. tech.	lb.	.11 – .14	.12 – .16
Lactic, 22 per cent. tech.	lb.	.05 – .06	.05½– .07
Molybdic, C. P.	lb.		4.00 – 4.25
Nitric, 40 deg.	lb.	.06 – .06½	.07 – .08½
Nitric, 42 deg.	lb.	.07 – .07½	.08 –
Oxalic, crystals	lb.	.23 – .25	.25 – .30
Phosphoric, Ortho, 50 per cent. solution	lb.	.09 –	.10 – .14
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.		2.30 – 2.60
Sulphuric, 60 deg., tank cars	ton	12.00 – 16.00	
Sulphuric, 60 deg., drums	ton	17.00 –	22.00 –
Sulphuric, 60 deg., carboys	ton	20.00 –	25.00 –
Sulphuric, 66 deg., tank cars	ton	17.00 –18.00	22.00 –23.00
Sulphuric, 66 deg., drums	ton	20.00 –21.00	25.00 –26.00
Sulphuric, 66 deg., carboys	ton	25.00 –	30.00 –40.00
Sulphuric, fuming, 20 per cent. (oleum) tank cars	ton	20.00 –	26.00 –
Sulphuric, fuming, 20 per cent. (oleum) drums	ton	25.00 –	32.00 –
Sulphuric, fuming, 20 per cent. (oleum) carboys	ton	30.00 –	35.00 –
Tannic, U. S. P.	lb.		1.35 – 1.45
Tannic (tech.)	lb.		.42 – .55
Tartaric, crystals	lb.		.73 – .74
Tungstic, per lb. of WO	lb.		1.20 – 1.40
Alcohol, Ethyl	gal.	4.80 – 4.95	5.50 –
Alcohol, Methyl	gal.	1.30 –	1.33 – 1.38
Alcohol, denatured, 188 proof	gal.	.66 –	.68 – .70
Alcohol, denatured, 190 proof	gal.	.62 –	.64 – .66
Alum, ammonia lump	lb.	.03½– .04½	.04½– .04½
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½– .02	.02½– .02½
Aluminum sulphate, iron free	lb.	.02½– .03	.03½– .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08 –	.08½– .09
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.		.30 – .35
Ammonium carbonate, powder	lb.	.13 – .13½	.14 – .14½
Ammonium chloride, granular (white salammoniac)	lb.	.12½– .13	.13½– .14
Ammonium chloride, granular (gray salammoniac)	lb.	.12 – .12½	.13 – .13½
Ammonium nitrate	lb.	.10 –	.11 – .12
Ammonium sulphate	lb.	.05 –	.06 –
Amyl acetate	gal.		3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.		.09 – .09½
Arsenic, sulphide, powdered (red arsenic)	lb.		
Barium chloride	ton	85.00 –	90.00 –100.00
Barium dioxide (peroxide)	lb.	.22 –	.24 –
Barium nitrate	lb.	.09½– .10½	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03½– .04
Bleaching powder (see calcium hypochlorite)			
Blue Vitriol (see copper sulphate)			
Borax (see sodium borate)			
Brimstone (see sulphur, roll)			
Bromine	lb.		.65 – .75
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.		.04½– .05
Calcium chloride, fused, lump	ton	19.00 –25.00	30.00 –40.00
Calcium chloride, granulated	lb.	.01½– .01½	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.		2.75 – 3.75
Calcium peroxide	lb.		1.50 – 1.70
Calcium phosphate, monobasic	lb.		.75 –
Calcium sulphate, precipitated	lb.		.09 – .09½
Carbon bisulphide	lb.	.05½–	.06 –
Carbon tetrachloride, drums	lb.	.10 – .11	.12 – .14
Carbonyl chloride (phosgene)	lb.		.75 –
Caustic potash (see potassium hydroxide)			
Caustic soda (see sodium hydroxide)			
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 –
Cobalt oxide	lb.		1.50 – 1.55
Copperas (see iron sulphate)			
Copper carbonate, green precipitate	lb.		.28 – .31
Copper cyanide	lb.		.65 – .70
Copper sulphate, crystals	lb.	.08½– .08½	.09 – .09½
Cream of tartar (see potassium bitartrate)			
Epsom salt (see magnesium sulphate)			
Formaldehyde, 40 per cent.	lb.		.32 – .37
Glauber's salt (see sodium sulphate)			
Glycerine	lb.		.24½– .26
Iodine, resublimed	lb.		4.50 –
Iron oxide, red	lb.		.03 – .20
Iron sulphate, (copperas)	cwt.	1.00 –	1.20 – 1.50
Lead acetate, normal	lb.		.12½– .14½
Lead arsenate (paste)	lb.		.13 – .17
Lead nitrate, crystals	lb.		.85 – .86½
Litharge	lb.		.09½– .10½
Lithium Carbonate	lb.		.50 –
Magnesium carbonate, technical	lb.		.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.00 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.12 –	.15 – .16
Phosgene (see carbonyl chloride)			
Phosphorus, red	lb.		.75 – .90
Phosphorus, yellow	lb.		.35 – .37
Potassium bichromate	lb.	.26 – .27	.30 – .33
Potassium bitartrate (cream of Tartar)	lb.		.55 – .60
Potassium bromide, granular	lb.		.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.25 –	.26 –
Potassium chlorate, crystals	lb.	.17 – .20	.21 –
Potassium cyanide, 98-99 per cent.	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.30 – .32	.35 – .40
Potassium iodide	lb.		3.55 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.		.55 – .65
Potassium prussiate, red	lb.		1.05 – 1.15
Potassium prussiate, yellow	lb.		$0.45 –$0.55
Potassium sulphate	ton	225.00 –	
Rochelle salts (see sodium potas. tartrate)			
Salammoniac (see ammonium chloride)			
Sal soda (see sodium carbonate)			
Salt cake (sodium sulphate)	ton	17.00 –21.00	
Silver cyanide	oz.		1.19 –
Silver nitrate	oz.		.76½–
Soda ash, light	100 lb.	2.00 –	2.05–
Soda ash, dense	100 lb.	2.25 – 2.35	2.50 – 2.75
Sodium acetate	lb.	.05½– .06½	.07 – .08
Sodium bicarbonate	100 lb.	2.60 –	2.75 – 3.00
Sodium bichromate	lb.		.38 – .42
Sodium bisulphate (nitre cake)	ton	3.00 – 8.00	10.00 –
Sodium bisulphite	cwt.	1.80 – 1.90	2.00 – 2.10
Sodium borate (borax)	lb.	.08 – .09	.08½– .09
Sodium carbonate (sal soda)	100 lb.	1.35 – 1.50	1.50 – 1.75
Sodium chlorate	lb.	.15 –	.16 – .18½
Sodium cyanide, 96-98 per cent.	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.		– 3.80
Sodium molybdate	lb.	2.50 –	3.25 –
Sodium nitrate	100 lb.	– 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	– .18
Sodium peroxide, powdered	lb.		.30 – .32
Sodium phosphate, dibasic	lb.	.03½– .04	.04½– .05
Sodium potassium tartrate (Rochelle salts)	lb.		.43 – .45½
Sodium prussiate, yellow	lb.	.24½– .26	.27½– .28
Sodium silicate, solution (40 deg.)	lb.	.01½– .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½– .03	.03½– .04½
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.15 – 1.25	1.50 – 2.00
Sodium sulphide, crystal, 60-62 per cent. (conc)	lb.		.05 – .06
Sodium sulphite, crystals	lb.	.03½–	.04 – .06
Strontium nitrate, crystals	lb.	.23 –	.28 –
Sulphur chloride	lb.	.05½–	.06 –
Sulphur, crude	ton	22.00 –	
Sulphur dioxide, liquid, cylinders	lb.		.10 – .12
Sulphur (sublimed), flour	100 lb.	3.10 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	2.95 –	3.15 – 3.40
Tin bichloride (stannous)	lb.	.44 –	.46 – .50
Tin oxide	lb.		.60 –
Zinc carbonate, precipitate	lb.		.20 –
Zinc chloride, gran.	lb.	.12½–	.13½– .14
Zinc cyanide	lb.	.49 –	.50 –
Zinc dust	lb.	.09 – .11	.11 – .14
Zinc oxide, dry American	lb.		.09½– .12
Zinc sulphate	lb.	.03½– .03½	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 — $1.10
Alpha naphthol, refined	lb.	1.40 — 1.50
Alpha naphthylamine	lb.	.32 — .50
Aniline oil, drums extra	lb.	.34 — .35
Aniline salts	lb.	.37 —
Anthracine, 80% in drums (100 lb.)	lb.	.90 — 1.00
Benzaldehyde (f.f.c.)	lb.	1.00 — 1.15
Benzidine, base	lb.	1.75 —
Benzidine, sulphate	lb.	.90 — 1.15
Benzoic acid, U. S. P.	lb.	.90 — 1.10
Benzoate of soda, U. S. P.	lb.	.80 — 1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 — .31
Benzol, 90%, in drums (100 lb.)	gal.	.25 — .29
Benzyl chloride, 95-97%, refined	lb.	.35 — .40
Benzyl chloride, tech	lb.	.25 — .35
Beta naphthol benzoate	lb.	3.75 — 4.50
Beta naphthol, sublimed	lb.	.75 — .80
Beta naphthol, tech	lb.	.45 — .55
Beta naphthylamine, sublimed	lb.	2.25 — 2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97-99%, straw color, in drums	gal.	.80 — .85
Cresylic acid, 95-97%, dark, in drums	gal.	.85 — .90
Cresylic acid, 50%, first quality, drums	gal.	.60 —
Dichlorbenzol	lb.	.07 — .10
Diethylaniline	lb.	1.40 — 2.25
Dimethylaniline	lb.	.80 — .85
Dinitrobenzol	lb.	.26 — .37
Dinitroclorbenzol	lb.	.25 — .30
Dinitronaphthaline	lb.	.45 — .55
Dinitrophenol	lb.	.32 — .36
Dinitrotoluol	lb.	.38 — .45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 — .65
Diphenylamine	lb.	.58 — .75
H-acid	lb.	1.60 — 1.75
Metaphenylenediamine	lb.	1.15 — 1.80
Monochlorbenzol	lb.	.12 — .15
Monoethylaniline	lb.	1.50 — 1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 — .08
Naphthaline, flake	lb.	.06½ — .07½
Naphthaline, balls	lb.	.08½ — .10
Naphthionic acid, crude	lb.	.75 — 1.25
Nitrobenzol	lb.	.14 — .19
Nitro-naphthaline	lb.	.40 — .45
Nitro-toluol	lb.	.27 — .20
Ortho-amidophenol	lb.	3.00 — 4.25
Ortho-dichlor-benzol	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.90 — 1.25
Ortho-nitro-toluol	lb.	.25 — .40
Ortho-toluidine	lb.	.25 — .45
Para-amidophenol, base	lb.	2.50 — 3.50
Para-amidophenol, HCl	lb.	2.50 — 3.25
Para-dichlor-benzol	lb.	.15 — .18
Paranitraniline	lb.	.95 — 1.10
Para-nitro-toluol	lb.	1.35 — 1.50
Paraphenylenediamine	lb.	2.50 — 4.00
Paratoluidine	lb.	1.75 — 2.50
Phthalic anhydride	lb.	1.50 — 2.15
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12½ — .16
Pyridin	gal.	2.00 — 2.50
Resorcin, technical	lb.	3.75 — 4.00
Resorcin, pure	lb.	6.50 — 6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.45 — .60
Salicylic acid, U. S. P.	lb.	.45 — .50
Salol	lb.	.90 — .95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.22 — .27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 — .24
Sulphanilic acid, crude	lb.	.25 — .30

Toluidine	lb.	$1.70	—	$2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	.....
Toluol, in drums	gal.	.32	—	.30
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42	—	$0 44
Beeswax, refined, yellow	lb.	47	—	.48
Beeswax, white pure	lb.	.64	—	.66
Carnauba, No. 1	lb.	.85	—	.87
Carnauba, No. 2, regular	lb.	.65	—	.78
Carnauba, No. 3, North Country	lb.	.48	—	.50
Japan	lb.	.18½	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	....	—	...
Paraffine waxes, crude, scale 124-126 m.p.	lb.	....	—	.06½
Paraffine waxes, refined, 118-120 m.p.	lb.	....	—	.09
Paraffine waxes, refined, 128-130 m.p.	lb	....	—	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	....	—	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	....	—	.13
Stearic acid, single pressed	lb.	.23	—	.26
Stearic acid, double pressed	lb.	.28	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.25		
Pine oil, pure, dest. dist.	gal.	1.00		
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.47		
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35		
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.65		
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38		
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.00		
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	....		
Pinewood creosote, ref.	gal.	.51		

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.00	—	$17.50
Rosin E-I	280 lb.	17.55	—	18.25
Rosin K-N	280 lb.	19.75	—	23.00
Rosin W. G.-W. W	280 lb.	22.50	—	24.25
Wood rosin, bbl.	280 lb.	17.00	—	17.50
Spirits of turpentine	gal.	1.65	—	1.66
Wood turpentine, steam dist.	gal.	1.63	—	....
Wood turpentine, dest. dist.	gal.	1.50	—	....
Pine tar pitch, bbl.	200 lb.	8.25	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	14.90
Retort tar, bbl.	280 lb.	15.00	—	15.25
Rosin oil, first run	gal.	.86	—	.91
Rosin oil, second run	gal.	.88	—	.93
Rosin oil, third run	gal.	.95	—	1.12
Rosin oil, fourth run	gal.	1.05	—	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½		
70-72 deg., steel bbls. (85 lb.)	gal.	.31½		
68-70 deg., steel bbls. (85 lb.)	gal.	.30½		
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½		

Crude Rubber

Para—Upriver fine	lb.	$0.53	—	$0.54
Upriver coarse	lb.	....	—	.35½
Upriver caucho ball	lb.	.34½	—	.35½
Plantation—First latex crepe	lb.	.51½	—	....
Ribbed smoked sheets	lb.	.51½	—	....
Brown crepe, thin, clean	lb.	.46½	—	.47½
Amber crepe No. 1	lb.	.49	—	....

Oils

VEGETABLE

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls.	lb.	$0.18½	—	$0.19
Castor oil, AA, in bbls.	lb.	.21½	—	.22
China wood oil, in bbls.	lb.	.22½	—	.23
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17½	—	.18½
Cocoanut oil, Cochin grade, in bbls.	lb.	.19½	—	.20
Corn oil, crude, in bbls.	lb.	....	—	.21½
Cottonseed oil, crude (f.o.b. mill)	lb.	.18	—	.19
Cottonseed oil, summer yellow	lb.	....	—	.27
Cottonseed oil, winter yellow	lb.	....	—	.28
Linseed oil, raw, car lots	gal.	....	—	1.87
Linseed oil, raw, tank cars	gal.	....	—	1.83
Linseed oil, boiled, car lots	gal.	....	—	1.90
Olive oil, commercial	gal.	2.50	—	2.80
Palm, Lagos	lb.	.17	—	.17½
Palm, bright red	lb.	.16½	—	.17½
Palm, Niger	lb.	.16	—	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½	—	.23½
Peanut oil, refined, in bbls.	lb.	.27	—	.28
Rapeseed oil, refined in bbls.	gal.	1.45	—	1.50
Rapeseed oil, blown, in bbls.	gal.	1.60	—	....
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.17½	—	.18½
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.15½	—	.15½

FISH

Winter pressed Menhaden	gal.	$1.20	—	.....
Yellow bleached Menhaden	gal.	1.23	—	....
White bleached Menhaden	gal.	1.25	—	.....
Blown Menhaden	gal.	1.26	—	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00	—	$40.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.03½	—	.04½
Blanc fixe, pulp	ton	30.00	—	50.00
Casein	lb.	.16	—	.18
Chalk, English, light	lb.	.05	—	.07
Chalk, English, light	lb	.04½	—	.06
Chalk, English, dense	lb.	$ .04	—	$ .05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	13.50	—	17.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	30.00	—	35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00	—	45.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	....
Shellac, TN	lb.	1.10	—	1.15
Shellac, D. C.	lb.	.....	—	....
Shellac, V. S. O.	lb.	.....	—	....
Shellac, Diamond I.	lb.	.....	—	....
Shellac, orange, fine	lb.	1.25	—	.....
Shellac, orange, superfine	lb.	1.20	—	1.30
Shellac, A.C. garnet	lb.	1.10	—	.....
Shellac, bleached, bone dry	lb.	1.35	—	.....
Shellac, bleached, fresh ground	lb.	1.10	—	1.15
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	60.00	—	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	80-90 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	35-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	30-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90 at Chester, Penn.
Silica brick	1,000	41-45 at Mt. Union, Penn.

Ferro-alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.25	—	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.70	—	.....
Ferro-manganese, 70-80% Mn	gross ton	110.00	—	115.00
Spiegeleisen, 16-20% Mn	gross ton	33.00	—	36.00
Ferro-molydenum, per lb. of Mo	lb.	3.00	—	3.50
Ferro-silicon, 50%	gross ton	85.00	—	95.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.25	—	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00	—	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	5.50	—	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60	—	$0.80
Chrome ore, 48% and over	unit	1.00	—	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00	—	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00	—	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	12.00	—	12.50
Fluorspar, gravel, f.o.b. mines	net ton	.....	—	25.00
Manganese ore, 45% Mn and over	unit	.50	—	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00	—	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00	—	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50	—	10.00
Uranium oxide, 96%	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	6.00	—	.....
Pyrites, foreign, lump	unit	.17	—	.....
Pyrites, foreign, fine	unit	.17	—	.....
Pyrites, domestic, fine	unit	.16	—	.17½
Ilmenite, 52% TiO_2	lb.	.02	—	.....
Rutile, 95% TiO_2	lb.	.11	—	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	.....
Monazite, per unit of ThO_2	unit	42.00	—	.....

*Government prices.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.80
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	16.00
Yellow pine, 3x4 to 8x8, 20 ft. and under	M.	48.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at Chicago	M.	50.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at St. Louis	M.	40 00
Roofings, tar felt (14 lb. per 100 sq.ft.)	ton	70.00
Roofings, tar pitch (in 400-lb. bbl.) carlots	ton	21.00
Roofings, asphalt pitch carlots	ton	34.00
Roofings, asphalt felt carlots	ton	63.00
Roofings, slate-surfaced, per roll of 108 sq.ft. carlots		2.25
Roofings, slate-finished shingles, 100 sq.ft. carlots		6.00
Linseed oil, raw in barrels	gal.	1.75
Linseed oil, 5 gal. cans	gal.	1.90
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.16½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil, 5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

NOTE—These items were compiled as of Dec. 12, but appear in this issue due to the delay in publication due to the printers' strike.

Connecticut

HARTFORD—The East Hartford District is having preliminary plans prepared for the construction of a 2-story, 62 x 124-ft. school with a 42 x 57-ft. ell. A chemical laboratory will be installed in same. Estimated cost, $200,000. Johnson & Burns, 174 Bond St., architects.

HARTFORD—The Hartford Fairmont Co., 41 Arch St., will soon award the contract for the construction of an addition to its glass manufacturing plant on Arch St. Estimated cost, $65,000. Ford, Buck & Sheldon, Inc., 60 Prospect St., engineer.

Illinois

CHICAGO — The Armour Fertilizer Works, Union Stock Yards, has awarded the contract for the construction of an acid plant to Westinghouse, Church, Kerr, Inc., 37 Wall St., New York City. Estimated cost, $150,000.

EAST ST. LOUIS—The St. Louis Pressed Steel Co., Merchants Exchange Bldg., has purchased a site at 26th and Bond Sts. and plans to build a steel mill. Estimated cost, $40,000. Fred Key, manager.

WEST FRANKFORT—The Board of Education will receive bids about Feb. 10 for the construction of a 2-story, 94 x 215-ft. school. A small laboratory will be installed in same. Estimated cost, $200,000.

Indiana

AETNA—The Aetna Iron & Steel Co., Gary, has awarded the contract for the construction of 1-story, 225 x 600-ft. and 75 x 400-ft. rolling mills here, to the Northwestern Bridge & Iron Co., 132nd and Hopkins St., Milwaukee, Wis. Estimated cost, $350,000.

HUNTINGBURG—The city is having plans prepared for the construction of a sewerage system and a disposal plant. Estimated cost, $75,000. C. Brossman, Merchants' Bank Bldg., Indianapolis, engineer.

Iowa

DES MOINES—A. Clemens, chairman of the Building Committee, care of Granette Products Co., 725 2nd St., has awarded the contract for the construction of a 80 x 120-ft. factory, for the manufacture of ornamental concrete products, at 9th and Murphy Sts., to J. E. Lovejoy, 1006 Mulberry St. Estimated cost, $30,000.

Kentucky

BOWLING GREEN—The Atlantic Producing & Refining Co. has purchased and will develop oil properties, also build additions to a plant for refining petroleum and manufacturing lubricating oil and wax. Estimated cost, $300,000. W. G. Williams, president.

Massachusetts

CAMBRIDGE—The G. H. Dyer Co., (welder) 155 Brookline St., has awarded the contract for the construction of a 2-story, 55 x 100-ft. factory and a 1-story, 30 x 40-ft. boiler house on Brookline St., to F. J. Van Etten Co., 153 Milk St., Boston. Estimated cost, $30,000.

EAST BOSTON (Boston P. O.)—I. Young & Co., 85 Border St., has awarded the contract for the construction of a 2-story, 74 x 80-ft. coppersmith factory on Border St., to Patrick Rich, 67 Byron St. Estimated cost, $28,000. Noted Oct. 22.

HOLYOKE—The Valley Paper Co., 2nd Level Canal, has awarded the contract for the construction of a 2-story, 50 x 350-ft. factory, to P. J. Kennedy & Co., 464 Maple St. Estimated cost, $70,000.

MEDFORD—The American Radio & Research Corporation, Medford Hillside, will soon receive bids for the construction of a 1 and 2-story, 140 x 200-ft. factory. Estimated cost, $90,000. H. F. Bryant, 334 Washington St., Brookline, engineer.

WATERTOWN—The Hood Rubber Co., Nichols Ave., has awarded the contract for the construction of two additions to its factory on Nichols Ave., one 3-story, 32 x 96-ft. and one 1 or 2 story, 60 x 220-ft. to the Aberthaw Construction Co., 27 School St., Boston. Estimated cost, $80,000.

WOBURN—The Buckman Tanning Co. is receiving bids for the construction of a sewage disposal plant. Estimated cost, $20,000. Vaughan & Meyer, Security Bldg., Milwaukee, engineers. Noted Oct. 29 and Nov. 5.

Michigan

BAY CITY—The Columbia Sugar Co., 508 Crapo Block, plans to construct a 1 to 3-story, 800 to 1000-ton capacity factory. A. H. Smith engineer.

Minnesota

MINNEAPOLIS — The Northwestern Glass Co., 219 Second St., N., plans to construct a 4-story, 66 x 162-ft. factory addition on 2nd Ave., and North 2nd St. Estimated cost, $100,000. Bertrand & Chamberlain, Northwestern Bank Bldg., architects.

Missouri

ST. LOUIS—The Sugar Products Co., 16 Exchange Pl., New York City, has awarded the contract for the construction of a 500,000-gal. molasses storage factory on Tesson & Van Buren Sts., to Murch Brothers Construction Co., Railway Exchange Bldg. Estimated cost, $125,000.

New York

FREYDENBURGH FALLS—The Farmers Standard Carbide Co. has retained W. E. Moore & Co., engineers, Union Bank Bldg., Pittsburgh, Pa., to prepare plans for the construction of a new carbide plant. The plant will be equipped with a Moore 3-phase carbide furnace, with a 30-ton per day capacity. The 46-ft. water fall will be developed for a capacity of 3700 hp. Crushing, screening and can-making machinery will be installed in same.

GENEVA—The Geneva Glass Products, Inc., plans to install glass-making and glass-handling equipment. Estimated cost between $15,000 and $20,000. Address R. S. Ellinwood, manager.

LONG ISLAND CITY—Dings & Schuster, 510 West 25th St., New York City, have awarded the contract for the construction of a 2-story, 56 x 84-ft. oil factory on 14th St., near Van Alst St., to the Aljou Construction Co., Inc., 51 East 42nd St., New York City. Estimated cost, $40,000.

LONG ISLAND CITY—The Pathe Exchange, Inc., 25 West 45th St., New York City, is having plans prepared for the construction of a laboratory and studio. Estimated cost, $700,000. Stone & Webster, 120 Broadway, New York City, architects and engineers. Noted Oct. 29.

THIELLS—L. F. Pilcher, State Architect, Capitol, Albany, has awarded the contract for furnishing chlorinating apparatus for the proposed addition to the sewage disposal plant at Letchworth Village, to the Suburban Engineering Co., 15 West 38th St., New York City.

Ohio

ASHTABULA—L. A. Amsden, city engineer, is preparing plans and will submit estimates for the construction of a sewage disposal system.

CAREY—The Carey Tire & Rubber Co. has awarded the contract for the construction of a 3-story, 80 x 160-ft. rubber factory, to C. N. Dennis, Tiffin. Estimated cost, $150,000.

CLEVELAND—The Glidden Varnish Co., West 110th St. and Berea Rd., has awarded the contract for the construction of a 3-story, 60 x 100-ft. factory on Berea Rd., to the Hunkin-Conkey Co., Century Bldg. Estimated cost, $600,000.

GREENVILLE—The city plans to construct a filtration plant. Estimated cost, $135,000. G. A. Johnson Co., 150 Nassau St., New York City, engineer.

Oregon

RICHLAND—The Town Council will soon award the contract for the construction of a waterworks system, including four miles of 8-in. supply main, steel or iron pipe, 50 water meters, connections, a 125,000-gal. per minute filtration plant, one mile of distributing system, etc. Estimated cost, $35,000. L. C. Kelsey, 410 Selling Bldg., Portland, engineer.

VALE—The Idaho Mutual Sugar Co. has purchased 4000 acres of land for beet growing and plans to build a 2 or 3-story, 500-ton daily capacity sugar factory on Dead Ox Flat. Estimated cost, $1,000,000.

Virginia

ORANGE—The city will soon award the contract for the construction of cast iron water mains from the town to the Rapidan River; also for the installation of a filtration plant and pumping station. Address A. J. Harlow, mayor. Sayville & Claiborne, 7th and Main Sts., Richmond, engineers. Noted Oct. 29.

West Virginia

PARKERSBURG—The Vitrolite Co. has awarded the contract for the construction of a 1-story, 200 x300-ft. factory addition, to Plote & Vogle, Parkersburg. Estimated cost, $300,000.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold a meeting in St. Louis from Dec. 26 to Jan. 1.

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23-26.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9, and 10.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York, Feb. 16-19.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting in St. Louis from Dec. 26 to Jan. 1.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

THE MINING AND METALLURGICAL SOCIETY OF AMERICA will hold a meeting in New York Jan. 13.

Industrial Notes

MUNN & Co., patent attorneys, Washington, D. C., Chicago and New York, announce that Mr. L. A. Paley has entered their office as one of their attorneys.

HAMILTON & HANSELL, INC., 13 Park Row, New York City, will from now on dedicate its entire business to metallurgical and general engineering work. In conjunction with domestic work, it will carry on development of foreign patents and enterprises. A separate company, namely, the American Transmarine Co., has taken over all the general export and import business not relating to engineering. For the past 5 years Hamilton & Hansell, Inc., has been licensee and builder of the American Rennerfelt electric furnace for ferrous and nonferrous work, and has also designed a number of electric reduction and electrochemical plants. The following contracts were closed during the last three months: One 1000-lb. 200-k.v.a. Rennerfelt furnace, for special iron, A. M. Byers Co., Pittsburgh, Pa.; one 200-k.v.a. Rennerfelt special furnace, for glazing fused silica, General Ceramics Co., Perth Amboy, N. J.; one 4-gross-ton, 1200-k.v.a. Rennerfelt furnace for tool steel, for export to Sweden; one 300-lb. 100-k.v.a. Rennerfelt furnace for aluminum alloys, Hauch Machine Tool Co., Springfield, Mass.; two 1000-lb. 200-k.v.a. Rennerfelt furnaces, for high speed steel (cast tools). U. S. High Speed Steel & Tool Corporation, Albany, N. Y.